2013-06

An analysis of training requirements and competencies for the Naval Acquisition Systems Engineering workforce

Alexander, Juli

Monterey, California: Naval Postgraduate School

http://hdl.handle.net/10945/34618

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

JOINT APPLIED PROJECT

An Analysis of Training Requirements and Competencies for the Naval Acquisition Systems Engineering Workforce

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By: Juli Alexander
June 2013

Advisors: Brad Naegle
Clifford A. Whitcomb

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** June 2013	**3. REPORT TYPE AND DATES COVERED** Joint Applied Project

4. TITLE AND SUBTITLE AN ANALYSIS OF TRAINING REQUIREMENTS AND COMPETENCIES FOR THE NAVAL ACQUISITION SYSTEMS ENGINEERING WORKFORCE	**5. FUNDING NUMBERS**
6. AUTHOR(S) Juli Alexander	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. government. IRB Protocol number ____N/A____.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

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It was found that a large gap in training exists. Only 27 percent of the KSAs needed by naval acquisition systems engineers are addressed in the SPRDE training curriculum and the SPRDE-SE curriculum does not accurately reflect the 29 competencies identified in the DAU SPRDE Competency Model. Less than half of the course objectives were consistently supported by associated learning objectives suggesting a weakness in the curriculum.

Proper training of this highly specialized workforce is imperative to assure successful acquisition programs. The DAU SPRDE curriculum provides DAWIA certification and some foundation but more must be done to provide comprehensive training.

14. SUBJECT TERMS systems engineering workforce, competency model, training requirements, systems planning, research, development and engineering (SPRDE)	**15. NUMBER OF PAGES** 107
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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AN ANALYSIS OF TRAINING REQUIREMENTS AND COMPETENCIES FOR THE NAVAL ACQUISITION SYSTEMS ENGINEERING WORKFORCE

Juli Alexander, Civilian, Naval Postgraduate School
BAA, Ohio University, 1982

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN CONTRACT MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 2013

Authors: ______________________________
Juli Alexander

Approved by: ______________________________
Brad Naegle

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Clifford A. Whitcomb

____
William R. Gates, Dean
Graduate School of Business and Public Policy

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ABSTRACT

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

ACQ101	Fundamentals of Systems Acquisition Management
ACQ 201A	Intermediate Systems Acquisition, Part A
ACQ 201B	Intermediate Systems Acquisition, Part B
ATL	Acquisition, Technology and Logistics
AWF	Acquisition Workforce
BKCASE	Body of Knowledge and Curriculum to Advance Systems Engineering
CDM	Competency Development Model
CDIO	Conceive, Design, Implement, Operate
CHSENG	Chief Systems Engineer
CNA	Center for Naval Analyses
CSEP	Certified Systems Engineering Professional
DACM	Director of Acquisition Career Management
DAG	Defense Acquisition Guidebook
DASD	Deputy Assistant Secretary of Defense
DASN	Deputy Assistant Secretary of the Navy
DAU	Defense Acquisition University
DAWIA	Defense Acquisition Workforce Improvement Act
DHS	Department of Homeland Security
DoD	Department of Defense
ELO	Enabling Learning Objective
ETA	U.S. Department of Labor, Employment and Training Administration
INCOSE	International Council on Systems Engineering
GRCSE	Graduate Reference Curriculum for Systems Engineering
HCSP	Human Capital Strategic Plan
NASA	National Aeronautics and Space Administration
NDAA	National Defense Authorization Act
NDIA	National Defense Industrial Association
NUWC	Naval Undersea Warfare Center

OFPP	Office of Federal Procurement Policy
OPM	Office of Personnel Management
OSD	Office of the Secretary of Defense
PCD	Position Category Description
PSE	Program Systems Engineering
RDT&E	Research, Development, Technology and Engineering
S&T	Science and Technology
SE	Systems Engineering
SEBoK	Systems Engineering Body of Knowledge
SecDef	Secretary of Defense
SPRDE	Systems Planning, Research, Development and Engineering
SYS 101	Fundamentals of Systems Planning, Research, Development and Engineering
SYS202	Intermediate Systems Planning, Research, Development and Engineering, Part I
SYS 203	Intermediate Systems Planning, Research, Development and Engineering, Part II
SYS 302	Technical Leadership in Systems Engineering
USD (A)	Undersecretary of Defense, Acquisition
USD (AT&L)	Undersecretary of Defense, Acquisition, Technology and Logistics

EXECUTIVE SUMMARY

This research examines the extent to which the Defense Acquisition University DAU Systems Planning, Research, Development, and Engineering (SPRDE) Systems Engineering (SE) training requirements for Defense Acquisition Workforce Improvement Act (DAWIA) certification accurately reflect the competencies needed to perform as a proficient systems engineer in the naval acquisition enterprise. Similarities and differences between the DAU SPRDE-SE training curriculum and the KSAs defined by the Naval Postgraduate School (NPS) SE Competency Model are analyzed and the corresponding gaps and overlaps in training are identified. As secondary objectives, the DAU SPRDE-SE training curriculum is further analyzed and compared to the DAU SPRDE Competency Model to determine the strength and consistency of the program itself. Finally, this research provides conclusions and recommendations as well as areas further research.

This research analyzed data drawn directly from the DAU iCatalog and compared and contrasted it with the knowledge, skills and abilities (KSAs) required to perform as a proficient naval acquisition systems engineer, as identified by the NPS SE Competency Model. It was found that substantial gaps exist in the training of this highly specialized workforce.

First, the cognitive and affective levels of the SPRDE-SE curriculum were compared to those of the KSAs in the NPS model. A considerable gap or lack of development of skills was found pertaining to the ability to apply knowledge and as well as all skills falling into the affective domain. These affective skills include abilities such as judgment, negotiation, and value which are crucial to the successful performance of systems engineers and are part of what separates systems engineers from other engineers.

Secondly, the DAU SPRDE-SE course and learning objectives were directly compared to the KSAs identified in the NPS SE Competency Model to determine more specific training gaps. It was found that a significant majority (73 percent) of these KSAs are not addressed by the DAU SPRDE-SE training curriculum.

To address the secondary research objectives, the cognitive levels of the SPRDE-SE Enabling Learning Objectives (ELOs) were compared to those of the overarching Course Learning/Performance Objectives (CL/POs) to determine whether the course learning objectives were supported by the curriculum. It was found that over half of the overarching CL/POs are comprised of inconsistent ELOs and that at least 12 percent of the CL/POs are not sufficiently supported by the underlying ELOs.

The DAU SPRDE-SE curriculum was then mapped to its own competency model to establish the level of strength and consistency in the DAU SPRDE program itself. It was found that five competencies in the DAU SPRDE Competency Model are not addressed in any way by the DAU SPRDE-SE curriculum and that 18 percent of the SPRDE-SE course objectives apply to competencies not included in the SPRDE model. This suggests that further research into the effectiveness and validity of the SPRDE-SE curriculum is warranted. Curriculum should be amended to include the competencies not currently addressed and additional competencies which are addressed by the curriculum should be added to the competency model.

Another important finding is that the DAU SPRDE-SE training curriculum is robust with regard to acquisition training. Approximately a third of the curriculum focuses on this essential competency. This is an important and highly desirable finding and helps to distinguish the DAU SPRDE Competency Model from other more generic systems engineering competency models.

The overarching problem addressed by this research is whether or not Systems Engineering competencies are being sufficiently developed by the SE workforce. Upper level concern exists that current training requirements for Systems Engineers are not sufficient to produce and support the high level SE workforce required for successful acquisition programs. This research has established that, while the DAU SPRDE-SE program provides DAWIA certification and some of the necessary training, it does not provide comprehensive proficiency training for this crucial sector of the acquisition workforce.

How and where higher cognitive and affective abilities are being developed needs to be determined as well as sources of training for the KSAs not addressed in DAU SPRDE certification program. These sources may include formal education, work experience and others. Furthermore, this research recommends a closer analysis of the DAU SPRDE program to insure that the associated educational objectives and outcomes are being achieved. DAU SPRDE-Se training is an important component of the overall competencies developed by the Naval systems engineering workforce. The validity and effectiveness of this training must be assured.

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ACKNOWLEDGMENTS

This project would not have been possible without the guidance and support of my advisors, Dr. Clifford A. Whitcomb and Professor Brad Naegle, LtCol, USA (Retired). Their generous contributions of time, insight, mentorship, patience, and faith were invaluable. I would also like to thank Professor Cory Yoder, CDR, USN (Retired) for his counsel throughout my Naval Postgraduate School career and to Ms. Ronda Spelbring for being my administrative champion. Finally, I would like to thank my friends and family for their infinite support and patience.

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I. INTRODUCTION

Workforce size is important but quality is paramount.

Ashton B. Carter (2010)

This chapter will provide a history of Department of Defense (DoD) acquisition workforce issues, the Defense Acquisition University and the Systems Planning, Research, Development, and Engineering (SPRDE) career fields. The evolution of both the SPRDE and Naval Postgraduate School (NPS) Systems Engineering (SE) Competency Models will be examined. This background information will reveal inherent problems in SE workforce training which will ultimately be addressed in this research. A broad problem statement will lead to research objectives and finally develop into specific research questions. This chapter will also address the importance of this research and methodology by which it will be conducted.

A. BACKGROUND

1. DAWIA and DAU

For over a half century, the U.S. Government has struggled to define and implement the training and education necessary to produce qualified, effective acquisition professionals. The post-war era brought an onslaught of heightened technology and complexity to the government acquisition arena and numerous studies were commissioned by Congress and the president to address deficiencies in the acquisition workforce; many of which have influenced our current acquisition workforce certification structure today. As early as 1955, the Hoover Commission highlighted the need for identification of procurement career paths and the 1972 Commission on Government Procurement reported that a university structure was required to further acquisition career management.

The 1980s, however, brought increasing acquisition scandal and Congress and the President were further compelled by public acrimony to produce meaningful improvements to the acquisition process. One outcome of these efforts was the

establishment of the Packard Commission. Lead by former Deputy Secretary of Defense David Packard, the Commission reported in 1986 that the Department of Defense (DoD) acquisition workforce (AWF) was undertrained, inexperienced and underpaid and their recommendations centered on the creation of a group of highly-trained, highly-skilled acquisition professionals. This counsel became the focus of the 1990 legislation that guides acquisition workforce development today (Layton, 2007, pp. 4–5).

Two other concurrent studies performed in the late 1980s had an important bearing on AWF career development; the *Defense Management Report*, conducted by the DoD, and the *Quality and Professionalism of the Acquisition Workforce*, conducted by the House Armed Services Committee. John Betti, then Undersecretary of Defense for Acquisition (USD (A), felt that previous reforms were unsuccessful because they were mandated by Congress rather than developed by the agencies themselves. Congress' issue with the resultant recommendations from the DoD was that they did not promote a unified approach; rather the DoD proposed training and education significantly different for each service. The concurrent House Armed Services Committee's report concluded that acquisition required professional skills and that, in addition to lack of college education, high turnover, and the underutilization of civilians, the inconsistent training and education programs of the various DoD agencies were causing major gaps in AWF career development. While the DoD balked at the implications of additional legislation, Congress was determined to implement statute-based acquisition training reform resulting in the Defense Acquisition Workforce Improvement Act.

The Defense Acquisition Workforce Improvement Act (Title 10 U.S.C. 1701-1764), also known as DAWIA, was introduced by Congressmen Nicholas Mavroules, a member of House Armed Services Committee, and was signed into law as a part of the 1991 National Defense Appropriation Act (NDAA) in November 1990. According to Mavroules, "Part of our intention in passing this legislation was to ensure that the sound, common-sense recommendations made by those numerous commissions are implemented" (Mavroules, 1991, p. 18).

DAWIA requires the DoD, acting through the Secretary of Defense (SecDef) and the Under Secretary of Defense (USD) for Acquisition, Technology and Logistics

(AT&L), to establish minimum education, training and experience requirements; to establish and maintain formal career paths for both military and civilian Acquisition Workforce members; to implement a formal certification process and to establish an acquisition corps of highly qualified acquisition professionals. It also mandates that a Defense Acquisition University is established and maintained to provide for "(1) the professional educational development and training of the acquisition workforce; and (2) research and analysis of defense acquisition policy issues from an academic perspective" (Title 10 U.S.C. 146). Finally, DAWIA also requires a collaborative, uniform approach between services. The overarching goal is to establish a professional, motivated, educated, highly-skilled, highly- trained acquisition workforce.

In 1991, the DoD Manual 5000.52-M, *Career Development Program for Acquisition Personnel* implemented DAWIA creating the Defense Acquisition University (DAU). The DAU incorporated several other defense agency schools that were active at the time to provide consistent training across all DoD agencies as required by DAWIA.

DAU certification is composed of three components; education, training and experience. All DoD personnel filing acquisition billets must be certified in the DAU career field assigned to that position within 24 months of employment. Training requirements may be satisfied by completing DAU courses, completing approved DAU equivalents such as several NPS programs, or satisfying the DAU fulfillment program which evaluates past experience, education and training against competencies associated with DAU courses.

2. Evolution of SPRDE-SE Career Field and Competencies

DAU initially defined 12 career paths, two of which fall under the science and engineering acquisition function and the oversight of the Deputy Assistant Secretary of Defense Systems Engineering (DASD [SE]): Systems Planning, Research, Development and Engineering—Systems Engineering (SPRDE-SE); and Production, Quality and Manufacturing (PQM) Career Fields. Systems Planning, Research, Development and Engineering—Program Systems Engineering (SPRDE-PSE) was introduced in 2007. The impetus for the creation of this additional career field is discussed in more detail below.

The DASD (SE) serves as functional leader for all three career fields. Supported by a Functional Integrated Product Team (FIPT), he advises USD (AT&L) with regard to competencies, certification standards and position category descriptions (PCDs). This research will focus on the certification requirements and curriculum of the SPRDE-SE career field in particular.

Original competencies and course design for the DAU career fields were outlined by functional boards made up of senior officials representing various acquisition organizations. These boards were responsible for:

- Ensuring each career field was properly developed and implemented
- Establishing the education, training, and experience standards for career paths
- Making recommendations to establish or disestablish mandatory courses
- Certifying annually to the USD (A) that the curriculum content and quality of each training course were current and complete (Layton, 2007, p. 33).

Using a competency-based model, DAU used Bloom's taxonomy to provide the framework for course development (Layton, 2007, p. 42). Level I certifications were structured to reflect basic knowledge, Level II built on that basic knowledge introducing practical application and small group scenarios, and Level III certifications were to develop synthesis and evaluation abilities.

In 2003, a joint summit of DoD and the National Defense Industrial Association (NDIA) found several critical areas of concern including that "complex education, training and recruitment issues exist: alignment of career paths, role of university education and DAU training resources is critical" (Defense Acquisition Workforce Report to Congress, Appendix 7, 2010, p. 7). It was discovered that while SE processes were sound, application of those processes was lacking. This report led the USD (AT&L) to initiate an extensive revitalization of DoD Systems Engineering. The SPRDE career field curriculum revision was completed in 2006 with the addition of four new courses: SYS 101, SYS 102, SYS 203 and SYS 302, all of which are now required at various levels of certification.

3. SPRDE-PSE Career Field

In an effort to further enhance systems engineering (SE) certifications, PCDs and competencies were examined and another issue in SPRDE career development was identified. For SPRDE-SE certification, DAWIA requires a baccalaureate or graduate degree in a technical field such as chemistry, engineering or computer science. Billets classified into the SPRDE-SE career field were extremely diverse and included workers from a wide array of technical fields. Job descriptions ranged from naval architect to computer scientist to operations research analyst to managing or supervising engineers. While this wide array of talent contributed to the strength of the workforce as a whole, identification of Systems Engineers possessing cross discipline experience and filling leadership roles at a program systems integration level was very difficult.

To help classify this specialized sector of the workforce, the SPRDE-PSE career field was created in 2007 (Director, Human Capital Initiatives, 2007, p. 1). The most noticeable difference from the SPRDE-SE requirements is the experience component of certification which is twice that of SE requiring two, four, and eight years for Levels I, II and III respectively. Two additional DAU courses or equivalents are also required at each certification level. The addition of this career field was intended to help identify and develop Systems Engineers capable of filling critical senior level positions.

4. SPRDE-SE/ PSE Competency Model

From the 2006 DoD (AT&L) Human Capital Strategic Plan initiative and the 2007 DAU curriculum revitalization, a SPRDE-SE/PSE competency model emerged. Developed by the Center for Naval Analyses (CNA), it was vetted by component subject matter experts (SMEs) in a National Defense Industrial Association (NDIA) SE Education and Training Working Group. This competency model was adopted by DAU and published in 2009 (Development of the SPRDE-SE/PSE Competency Model, 2009). Consisting of 29 technical and professional competencies and 45 competency elements, this model was then used as the foundation for a competency model assessment that was administered by CNA to the SPRDE-SE/PSE workforce in December 2010 through March 2011 (Lasley-Hunter, 2011). This survey was designed to gather data regarding

proficiency, mission criticality and frequency of the identified competencies and was administered to both employees and supervisors. The methodology and results of this survey will be discussed further in Chapters II and III.

5. Naval Acquisition Systems Engineering Competency Model

There is consensus between NPS SE subject matter experts and Deputy Assistant Secretary of the Navy (DASN) Research, Development, Test and Evaluation (RDT&E) Chief Engineer (CHENG) that the required competencies and certifications for proficient DON systems engineers need to be examined. As Chief Engineer for the Navy, DASN (RDT&E) desires a concrete definition of what systems engineers do and how they develop over their careers. As part of a DASN (RDT&E) Strategic Initiative, a team from NPS's Systems Engineering Department is developing an overall approach to the design of a naval systems engineering competency model. This model will be referred to in this research as the NPS SE Competency Model.

Any study for the development of a Naval Systems Engineering Competency Model must include SPRDE-SE learning objectives, the degree to which they reflect actual competencies needed to perform as an acquisition systems engineer, the impact they are having or could have on SPRDE acquisition workforce members, and how various members fit into the current DAU certification structure. Even though there is a desire to train both systems engineers and non-technical workforce members in some aspects of systems engineering in the context of systems acquisition to allow people in technical fields that do not fit into any of the current career paths access to basic acquisition training.

The NPS Team, led by Professor Clifford Whitcomb, first identified five SE competency models:

- SE Workforce Development Naval Underwater Warfare Center (NUWC)
- International Council on Systems Engineering (INCOSE)
- National Aeronautics and Space Administration (NASA)
- DAU SPRDE
- Boeing Company

Elements of all five competency models were analyzed, categorized and duplications were eliminated. The competency model that emerged was mapped to the 29 SPRDE competencies plus two additional competencies: “Systems Thinking” and “Interpersonal and Personal Characteristics.” The NPS SE competency model team identified 2151 KSAs that fall into these 31 competencies. The current iteration of the NPS SE Competency Model only includes a study to the level of the 29 competencies and 45 elements. Further study is needed at the level of the DAU SPRDE learning objectives to define and integrate these into the model as new KSAs. The evolution and development of this NPS SE Competency Model will be addressed in more detail in Chapter II.

6. Summary

This section has presented the background of the SPRDE-SE career field and Competency Model. Figure 1 summarizes the evolution of the SPRDE-SE Competency Model.

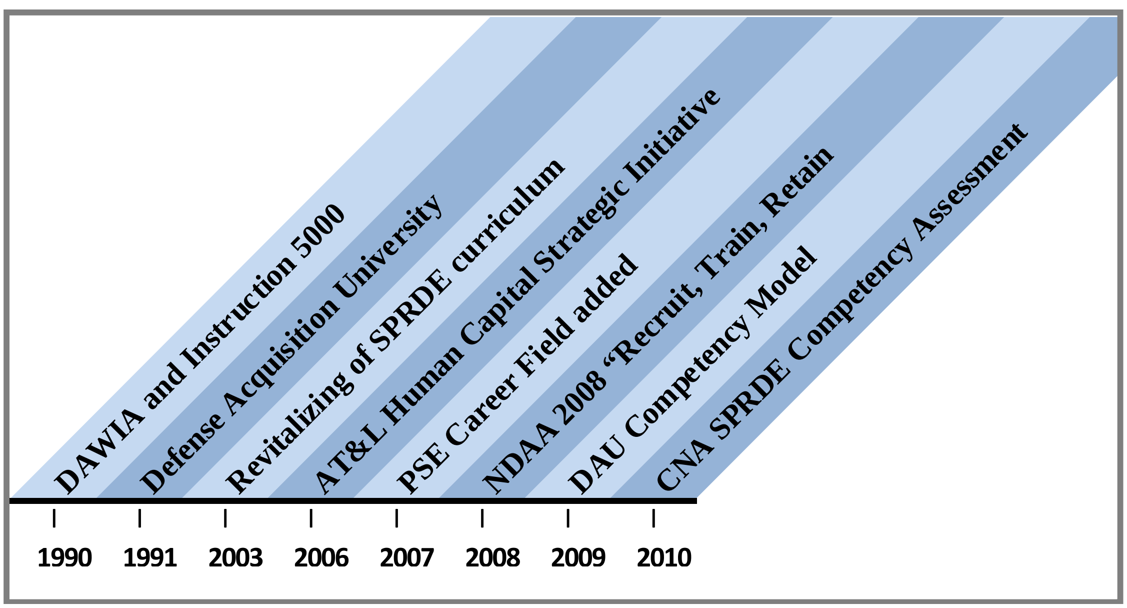

Figure 1. Evolution of the SPRDE-SE Competency Model

The importance of training a well-qualified, professional acquisition workforce has been recognized for decades. Certification processes have been developed and

revitalized; however, there is still upper level concern that current knowledge, skills and abilities for Systems Engineers are not sufficiently and consistently well-defined to produce and support the technically competent SE workforce required to support acquisition program success.

Current research has identified a Naval Systems Engineering Competency Model and the KSAs required to perform successfully as a naval systems engineer. As a logical progression, this project will compare the NPS defined KSAs and the current DAU training course objectives to determine the similarities, differences, gaps and overlaps between current training and the capabilities needed to perform as a successful naval systems engineer.

B. PROBLEM STATEMENT

Professor Robert L. Hawkins, Director of Curriculum Development at DAU, summarized the situation:

> The pure-and-simple politics of acquisition education is that many have viewed it as a deficient system that has failed to make clear what all students need to learn and whether, in fact, they have learned it….The most fundamental problem is our schools are accountable only for educational processes, not educational outcomes. (Hawkins and Granzo, 1997)

While DAU has designed and implemented training programs that satisfy DAWIA requirements, the outcomes of those training programs are not necessarily targeted to the development of highly educated, professional, technically competent systems engineers in the acquisition workforce.

The overarching problem is whether or not Systems Engineering competencies are being sufficiently developed in the SE workforce. To address this issue, we must first define what these competencies are. Initially, this requires the definition of what competencies are needed to perform as a proficient systems engineer. This scope can then be narrowed to ask what competencies are needed to perform as a proficient naval systems engineer and further yet to what competencies are needed to perform as a proficient naval *acquisition* systems engineer.

Once these competencies are defined, they must be compared to DAU SPRDE training currently in place to identify gaps and overlaps in overall SE workforce development. As these gaps and overlaps in the current training are recognized, progress can be made toward adapting training and thereby improving the quality of the systems engineering workforce.

C. RESEARCH OBJECTIVES

The primary objective of this research is to determine the extent to which the DAU SPRDE-SE training objectives for DAWIA Certification provide a basis for defining KSAs needed to perform as a proficient acquisition systems engineer in the naval acquisition enterprise. To support this objective, similarities and differences between DAU SPRDE-SE training objectives and NPS SE Competency Model KSAs will be examined and overlaps and gaps will be identified. This objective is illustrated in Figure 2.

The secondary objective of this research focuses on an internal analysis of the DAU SPRDE program. To this end, the consistency of the DAU SPRDE curriculum will be studied to analyze the extent to which the DAU Enabling Learning Objectives (ELOs) support the Course Learning / Performance Objectives (CL/POs). Subsequently, the extent to which the DAU curriculum reflects the DAU SPRDE-SE Competency Model will be examined. The secondary research objective will provide a high level review of the DAU SPRDE program and its learning objective consistency.

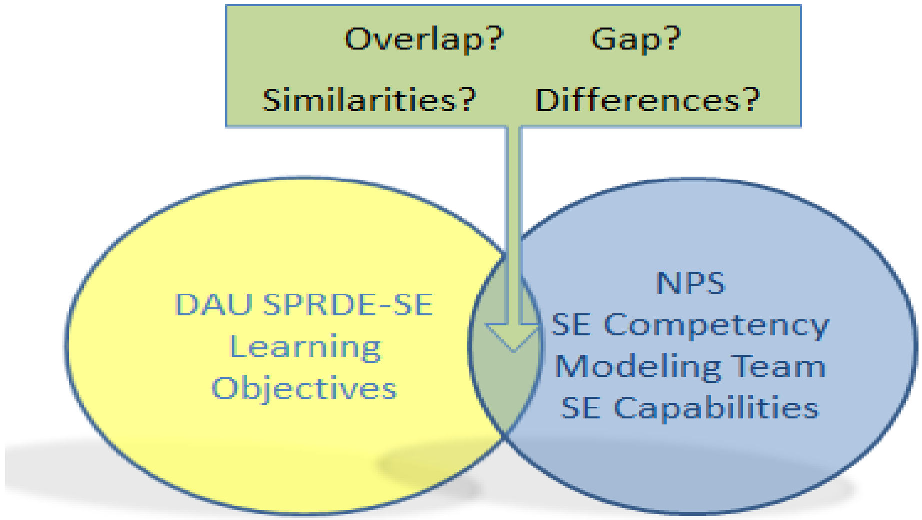

Figure 2. Illustration of the Relationships defining the Research Objectives

D. RESEARCH QUESTIONS

The background of this topic has presented several issues that were considered in the formulation of the research questions. The following research questions have been developed in response to the previously outlined research objectives. These research questions will guide the path of this research which will culminate in their answers and conclusions provided in Chapters IV and V.

1. Primary Research Questions

The primary research questions both involve a comparison of the DAU SPRDE-SE curriculum and the NPS SE Competency Model.

Primary Research Question 1: To what degree do the DAU SPRDE-SE training requirements for DAWIA Certification reflect the competencies needed to perform as a proficient systems engineer in the naval acquisition enterprise as identified by the NPS SE Competency Model?

Primary Research Question 2: What are the similarities and differences between DAU SPRDE-SE curriculum and NPS SE Competency Model KSAs? What is the overlap or gap between these models?

2. Secondary Research Questions

In studying the DAU curriculum and competency model, a set of related, secondary research questions have been developed that provide insight into the characteristics of the DAU training curriculum and the DAU SPRDE Competency Model. This internal DAU SPRDE evaluation presents the secondary research questions.

Secondary Research Question 1: To what extent are the DAU SPRDE-SE Course Learning/Performance Objectives supported by their corresponding Enabling Learning Objectives?

Secondary Research Question 2: To what extent do the DAU SPRDE-SE Course Learning/ Performance Objectives reflect the DAU Competency Model?

E. PURPOSE/BENEFIT

This section defines Systems Engineering and discusses the impact of its workforce on the acquisition enterprise. Several stakeholders' initiatives or interest in the development of acquisition workforce development will also be examined.

The concept of Systems Engineering was introduced in the mid-1950s by the dramatic upswing in technological complexity. In his book "Rescuing Prometheus", Thomas P. Hughes describes four post-war technological projects that have helped to shape modern day management styles. The Atlas Project developed the first intercontinental ballistic missile and involved over 70,000 workers in 22 different industries along with 500 military officers. Hughes asserts, "From Atlas, a new mode of management known as systems engineering emerged and has spread…even into government agencies" (Hughes, 1998, p. 4). The SAGE air defense project was the first computer application that reached beyond computation to the running of processes and systems. SAGE exemplified the Systems management structure that would ensure integration and compatibility throughout the entire product life-cycle from research and development through design and performance.

To narrow our perspective to DoD application, the *Defense Acquisition Guidebook* (DAG) defines Systems Engineering as:

- A methodical and disciplined approach for the specification, design, development, realization, technical management, operations, and retirement of a system.
- SE applies critical thinking to the acquisition of a capability. It is a holistic, integrative discipline, whereby the contributions across engineering disciplines…are evaluated and balanced to produce a coherent capability—the system.
- SE balances the conflicting design constraints of cost, schedule, and performance while maintaining an acceptable level of risk (Defense Acquisition Guidebook, 2013, p. 4).

The DAG points out that not only is SE applied throughout the entire lifecycle of an acquisition program, but it also involves many of the different component processes from design to risk to budget. SE is integral to a number of acquisition policies and it is the "glue" that holds acquisition programs together. A professional, well-trained SE workforce is crucial to the success of acquisition programs.

In addition to the scope of Systems Engineering, the sheer magnitude of the SPRDE-SE workforce impacts the success of the defense acquisition process. Figure 3 illustrates the size of the SPRDE-SE workforce in relation to the other 15 career fields and to the Defense Acquisition Workforce as a whole. SPRDE-SE represents, by far, the largest component of the AT&L workforce with over 39,000 workers. The size of this sector magnifies the importance of adequate and accurate training.

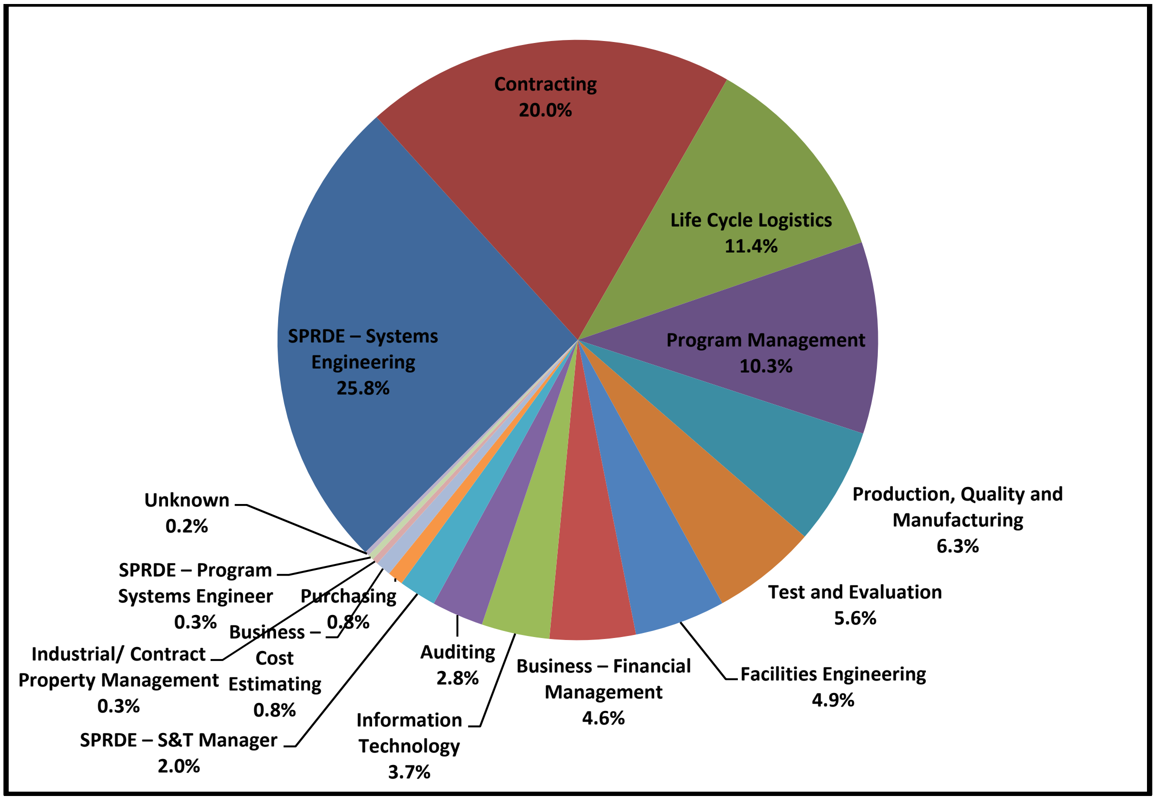

Figure 3. Defense Acquisition Workforce by Career Field (Defense Acquisition Workforce Update, 2012)

Another issue that highlights the importance of this research is the impending departure of Baby Boomers from the AWF. The 1990s saw a dramatic drawdown in the size of the acquisition workforce. This downsizing included a curtailment of new hires, which in turn has left a gap in the continuum of workforce age. Currently, a large percentage of the AWF is close to or already eligible for retirement and behind them is a vacuum of talent reflecting a decade when younger workers were not being hired. The SPRDE Workforce Assessment found that at least 11 percent of the SPRDE workforce will retire by 2016 (Lasley-Hunter, 2011, p. 5). This effect is even more pronounced at upper levels of management and presents yet another challenge to the establishment and maintenance of a quality workforce (Gansler, 2002). Effective certification and training requirements identified by this research are needed to help fill this gap in expertise.

While the scope of Systems Engineering and the size of the SE workforce shed a crucial light on the importance of sound SE education and training, it is also important to take note of stakeholders that are proponents of this research area.

Stephen Welby, Deputy Assistant Secretary of Defense (DASD) for SE, as the Functional Leader for SPRDE-SE and PSE career fields, states:

> One of our greatest challenges may be in our approaches to building great people and teams and improving how we recruit, grow, and mature the technical and systems engineering professionals who will successfully deliver today and tomorrow's critical defense systems (Office of the Deputy Assistant Secretary of Defense Systems Engineering (ODASD [SE], 2013).

Two of the top priorities of the DASD (SE) are to (1) champion SE as a tool to improve acquisition quality and (2) develop future technical leaders across the acquisition enterprise. One of his strategies to accomplish these goals is to identify "workforce competencies crucial for executing systems engineering and production, quality, and manufacturing functions within acquisition programs." Clearly, examination of these competencies is paramount to achieving these goals (ODASD [SE], 2013).

In 2010, USD (AT&L), then Ashton Carter, introduced the Better Buying Power Initiative in which he highlighted the need for the DoD to develop efficiencies in procurement spending or "to do more without more." It has been revised as recently as April 2013 and highlights seven focus areas including "Improve Professionalism in Acquisition Workforce" (Defense Acquisition University [DAU], 2012). Ashton Carter coined the phrase, "Workforce size is important, but quality is paramount" (Carter, 2010). Carter's focus on the importance of AWF development reflects on the importance of this research.

The DASN (RDT&E), a senior advisor to the ASN (RD&A), oversees the DON Chief Engineer (CHENG) position and is the functional Acquisition Workforce Competency Leader for Engineering. The DASN (RDT&E) is actively involved in engineering workforce development and, as a primary stakeholder, is sponsoring current research at NPS. As part of the DASN (RDT&E) Strategic Initiative entitled, "Initial Development of Systems Engineering Competency Model," the NPS research is tasked to

determine precisely what it is that systems engineers do; how that compares with training currently being provided through DAU certification; what the overlaps and gaps are and how those training gaps can be addressed. This research is a vital part of answering those questions. The competency model being developed by the NPS team is integral to this research and will be discussed at length throughout this paper.

The ATL Human Capital Strategic Plan, initiated by USD (AT&L) in 2006 and revised in 2010, identified "Mission-responsive workforce strategies and development" as one of the five goals (AT&L HCSP, 2010). This research applies to workforce development.

As the government experiences more budgetary constraints, increasingly complex technological developments, reductions in the experience level of the acquisition workforce due to retirement, getting Acquisition right will become more and more crucial. The first step to improving the outcomes is to ensure a qualified, professional, well-trained workforce.

While DAWIA and DAU have provided huge improvements in acquisition training, much remains to be done. This study will examine the similarities and differences, gaps and overlaps between the knowledge, skills and abilities that are required for SPRDE-SE certification and those which have been identified as being necessary to perform successfully as a naval systems engineer. In providing insight into areas of training needed for Systems Engineers beyond the DAU SPRDE-SE certification this research will help move towards the overlying goal of establishing a professional, well-trained acquisition workforce.

F. SCOPE/METHODOLGY

This research will conduct a comparative analysis of the course performance and learning objectives required for DAU's SPRDE-SE Level I, II and III Certification and the knowledge, skills and abilities defined by the NPS SE Competency Modeling Team as necessary to the successful performance of a naval acquisition systems engineer. First, the DAU CL/POs and ELOs and the NPS Team's KSAs will be categorized according to Bloom's Taxonomy. A determination will be made as to the extent of similarities and

differences between the two sets of data with respect to Bloom's Cognitive and Affective Domains. Secondly, the DAU CL/POs and ELOs will be compared directly with the NPS KSAs to determine the overlap and/or gap between the two.

To address the secondary research questions, the cognitive level categorizations of the DAU CL/POs will be compared directly to the corresponding ELOs to determine to what degree the ELOs support the cognitive levels of the CL/POs. Finally, the DAU CL/POs will be categorized according to the DAU SPRDE competency model and that data will be analyzed to determination how well the 29 DAU competencies are represented in the DAU SPRDE-SE curriculum.

The data used for this research is limited to the required courses for SPRDE-SE Levels I, II and III certification. The SPRDE-PSE certification requirements are inclusive of and build upon the SPRDE-SE objectives by adding two additional elective training classes at each certification level and doubling the required years of experience. Hence, by analyzing the SPRDE-SE curriculum, the foundation for both certifications is being examined.

While DAWIA certification requirements include elements of education, training and experience, this research will focus on training component of certification. Further research is required to determine the extent to which experience and education satisfies the desired competencies for SE.

G. THESIS STATEMENT

This study will analyze and determine to what extent the DAU SPRDE-SE Certification curriculum provides the basis for defining KSAs to support the development of for Naval Systems Engineers. In addition, Bloom's Cognitive Domain levels of the objectives in the DAU curriculum will be compared internally, to examine the degree to which the DAU Course Objectives are supported by the curriculum, as well as to the NPS SE Competency Model Team's KSAs, to determine the overlap and/or gap in KSA coverage. Finally, the DAU curriculum will be compared with the DAU competency model to determine the extent to which all 29 competencies are being addressed.

H. REPORT ORGANIZATION

Chapter I of this research provides background to the problem and defines the research objectives and questions. Chapter II will take a closer look at the tools used in the analysis of this study. Chapter III will present the data and methodology used in the analysis. Chapter IV will discuss the findings of the analysis and finally, Chapter V will reveal conclusions and provide suggestions for further research.

I. SUMMARY

This chapter has reviewed the evolution of the SPRDE-SE career field and the DAU SPRDE Competency Model as well as the background of the NPS SE Competency Model. A problem statement has been refined into research objectives and research questions and the importance of this study and stakeholders have been examined. Finally, the scope and methodology were set forth and the thesis statement defined. Next, we will take a closer look at the tools used in this analysis.

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II. LITERATURE REVIEW

Chapter I provided a background for this research by explaining the series of events that culminated in the issues addressed by this research's objectives. This chapter will focus on current literature surrounding the tools used in our analysis. First, we will take a closer look at competency models in general, how they are developed and how they are assessed. Next, two competency models in particular will be examined; the DAU SPRDE Competency Model and the NPS SE Competency Model. Finally, we will review Bloom's Taxonomy of Educational Objectives and why it was chosen as a comparative framework for this research.

A. COMPETENCY MODELS AND ASSESMENTS

This section will define competencies and competency models and discuss their characteristics and uses. The DAU SPRDE-SE Competency Model will then be examined in more detail to gain a deeper understanding of this element of this study's analysis.

The Office of Personnel Management (OPM) describes a competency as "an observable, measurable pattern of skills, knowledge, abilities, behaviors and other characteristics that an individual needs to perform work roles or occupational functions successfully" (Lasley-Hunter, 2011, p. 8). The Cambridge English Dictionary provides a more succinct definition: "an important skill that is needed to do a job."

The Department of Labor, Employment and Training Administration defines a competency model as "a collection of competencies that together define successful performance in a particular work setting (Develop a Competency Model, 2013).

Competency models are valuable for many reasons. Competency models provide the framework for competency assessments. Common uses include the support of many Human Resource functions such as recruitment and hiring, job training and performance evaluations and career development. Competency assessments provide a framework to demonstrate professionalism and instill confidence in both workers and customers. Another interesting application is the realistic reflection of individual competency. Studies have shown that incompetent people see themselves as being more competent

than they are while competent people see themselves as less competent than they are (Kruger, 1999). Accurate competency assessments allow management to allocate personnel resources in a more realistic and effective manner. Competency assessment is "the key to an organization's overall capability improvement" (Holt, 2011, p. xvi).

Now that we know what competency models are and what they are used for, we will examine their characteristics and components. Competency models can be specific or general with applications ranging from a specific job to a job group to an occupation to an industry. Most competency models use some type of representative visual diagram and include a reference to different levels of mastery, such as entry level, mid-level or highly experienced. They are typically made up of competency names with detailed definitions and detailed descriptions of activities or behaviors associated with each competency, sometimes referred to as KSAs or elements (U.S. Dept. of Labor, 2013). A competency element is a behavioral statement describing a cluster of related tasks that results in an outcome of high value (SPRDE-SE/PSE Competency Assessment Employee Users Guide, 2010).

The OPM defines KSAs as the following:

- **Knowledge, Skills and Abilities (KSAs)** are the attributes required to perform a job and are generally demonstrated through qualifying service, education or training.
- **Knowledge** is an organized body of information applied directly to the performance of a function. \
- **Skill** is an observable competence to perform a learned psychomotor act.
- **Ability** is the competence to perform an observable behavior or a behavior that results in an observable product.

Beyond these basic components, *good* competency models also include other traits. Typically, they combine skills from several different sources and the frameworks have evolved through many iterations. They apply across different levels of proficiency but are still simple and easy to understand. Finally, Holt characterizes good competency models as those that focus on specific, technical skills rather than general, professional,

human skills (Holt, 2011). Others in the field believe that while soft skills may not belong in a core technical competency model, they are needed and belong in a competency model of their own.

The U.S. Department of Labor, Employment and Training Administration (ETA) User Guide to Competency Models (Develop a Competency Model, 2013) shows five steps to developing a competency model as shown in Figure 4.

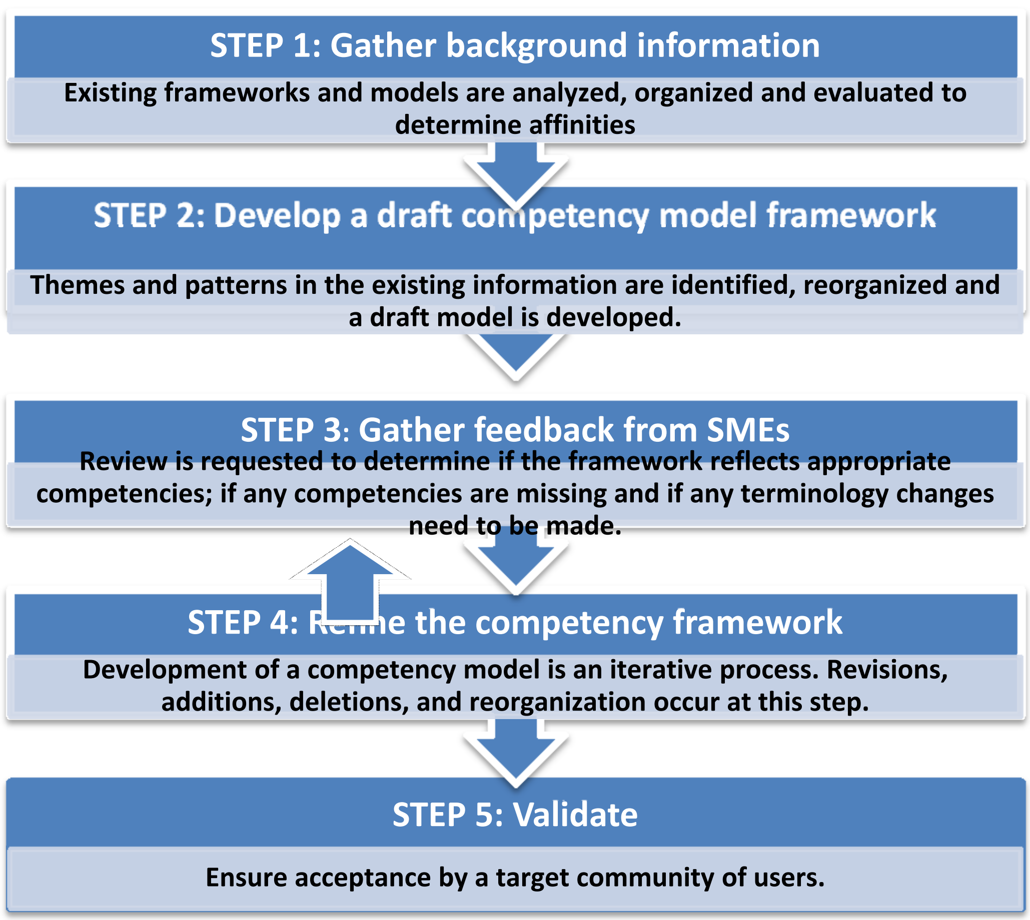

Figure 4. Competency Model Development Steps

Note that steps 3 and 4 are repeated until the SMEs and the development team agree that the model is an all-inclusive representation of required KSAs. Later in this

section, two competency models will be examined; the DAU SPRDE Competency Model and the NPS SE Competency Model, and we will see how these five developmental steps have been implemented.

Competency models provide the framework for competency assessments. A competency assessment is an application or comparison of a competency model to a worker's or workforce's capabilities. Good competency assessments are repeatable, providing for accurate comparison; measurable; based on best practices; traceable to standards and frameworks; transferable between frameworks and tailorable. Ideally, competency assessments will be as flexible and scalable as possible. Competency assessment output is a worker profile. This profile is not a "pass/fail" audit but rather it paints an overall picture of an employee's strengths and weaknesses, gaps in training and the level of their career development (Holt, 2011, p. 8).

This section has provided an overview of competency models and competency assessments; what they are used for, what they consist of, how they are developed and what defines a *good* one. Now we will examine the two competency models used in the analysis of this research to better understand these particular models and their impact on this research.

B. DAU SPRDE COMPETENCY MODEL DEVELOPMENT AND ASSESSMENT

Because the DAU SPRDE Competency Model plays a significant role in this research, it warrants a deeper examination. In the analysis for the fourth research question, a direct comparison is made to see if the DAU SPRDE-SE curriculum is representative of and supports the DAU SPRDE Competency Model. The DAU SPRDE Competency Model is also the foundation or original framework for the NPS SE Competency Model as will be discussed in the next section. The primary research objective involves comparisons with the NPS SE Competency Model and therefore that analysis will be indirectly affected by the DAU SPRDE Competency model as well. Because the DAU SPRDE Competency Model is woven throughout this research, it is important to understand its development and characteristics before we begin to use it as a

tool. This section will also examine the findings of the associated competency assessment and the impact these characteristics and findings have on our research.

As mentioned in Chapter I, the DAU SPRDE Competency model was a result of SE curriculum revitalization efforts and the 2006 DoD (AT&L) Human Capital Strategic Plan initiative. The formulation of the DAU SPRDE Competency Model is illustrative of the developmental steps presented previously in Figure 4. Initially a small group of career field experts and leaders identified behaviors, knowledge, skills and characteristics required to be a successful SPRDE employee and created a framework. The group was then expanded to include successful workforce members and the model was analyzed, added to, deleted from and compared directly to job responsibilities. Further refinements and revisions finally resulted in the competency model shown in Figure 5 that includes 29 competencies categorized into 3 competency units; analytical, technical management and professional. The model also includes 45 unique elements which apply to the various competencies. A full version of this model, including elements, is available in Appendix A (Lasley-Hunter, 2011, pp. 12, 83–87).

Competencies in the Analytical Unit of Competence		Competencies in the Technical Management Unit of Competence		Competencies in the Professional Unit of Competence	
1	Technical Basis for Cost	14	Decision Analysis	26	Communications
2	Modeling and Simulation	15	Technical Planning	27	Problem Solving
3	Safety Assurance	16	Technical Assessment	28	Strategic Thinking
4	Stakeholder Requirements Definition (Requirements Development)	17	Configuration Management	29	Professional Ethics
5	Requirements Analysis (Logical Analysis)	18	Requirements Management		
6	Architectural Design (Design Solution)	19	Risk Management		
7	Implementation	20	Technical Data Management		
8	Integration	21	Interface Management		
9	Verification	22	Software Engineering		
10	Validation	23	Acquisition		
11	Transition	24	System Engineering Leadership		
12	System Assurance	25	System of Systems		
13	Reliability, Availability, and Maintainability (RAM)				

Figure 5. DAU SPRDE Competency Model

Two characteristics of this model are particularly worthy of note. First, this model includes both technical and professional competencies. Technical competencies are

functional and specific to a career field. Professional competencies, such as leadership, communication, problem solving and ethics, apply to all engineering career fields and are also referred to as "soft skills." In the previous section, it was noted that *good* competency models emphasize technical skills rather than "soft" professional skills. This model characteristic will be discussed in greater depth in the next section as we discuss the development of the NPS SE Competency Model. Suffice it now to understand that 4 of the 29 competencies in the DAU SPRDE Competency Model reflect these "soft skills" or professional competencies. Secondly, this model does not address different levels of proficiency, which is another characteristic of *good* competency models. There is no distinction between the competencies needed at entry-level as opposed to the competencies needed by an expert in the SPRDE field.

In December 2010, at the fourth stage of DAU SPRDE Competency Model development and validation, the CNA administered a competency model assessment to the SPRDE workforce. It important here to clarify terminology that might be confusing. As discussed previously, competency models are used for competency assessments which measure worker or workforce capabilities. This assessment was an evaluation of the DAU SPRDE Competency Model itself, rather than the workforce.

The CNA survey was designed to determine self-assessed proficiency, criticality, and the frequency of performance of each of the 29 competencies and 45 elements in the DAU SPRDE Competency Model. Data on proficiency and criticality was also collected from supervisors; however, a low response rate resulted in the exclusion of this data in the final analysis. Additionally, demographic information was collected from the respondents to assist in other assessment goals, such as the development of a workforce profile and workforce size and proficiency projections. The final analysis of the DAU SPRDE Competency Assessment was reported by CNA in 2011. Several of these findings are worthy of note in the context of this research.

First, with regard to validity, the assessment was completed by over 10,000 employees representing approximately 27 percent of the SPRDE workforce. Although it was determined that the number of employee responses is "highly representative" of the overall SPRDE workforce population, the size of the sample should be taken into

consideration when applying these results to the entire SPRDE workforce (Lasley-Hunter, 2011, pp. 1–2, 14). There seems to be no definitive evidence as to what segment of the workforce responded to the assessment; whether the respondents were a true random sample or whether the respondents were possibly a pool of workers that may have been less engaged, less pressured, or had fewer responsibilities in their jobs and consequently had more time to complete an online assessment. The low rate of supervisory response seems to support this possibility. Because no data was recorded as to the makeup of the respondents, the findings of this assessment may have been somewhat skewed.

Secondly, as part of the demographic analysis, it was found that over half of the SPRDE workforce has obtained a Master's degree or higher and that 87 percent of the highest degrees obtained were in science, technology, engineering, or math (Lasley-Hunter, 2011, p. 30–31). The significance of this finding stems from the fact that education is one of three components of DAWIA certification in conjunction with training and experience. The scope of this paper is limited to examination of the training element and how it relates to needed competencies. Overarching research evaluating workforce capability would need to take into consideration the high education levels of this workforce as well as skills gained on the job. The assessment also found that 57 percent of the SPRDE workforce is certified at Level III which suggests that perhaps this "expert" Level is too easily attained. Higher levels of certification may be warranted and/or the content of these Levels may need readjustment.

Next, respondents from the SE workforce community rated each of the 29 competencies with regard to criticality and frequency of use. These parameters were combined to deduce "importance". Only seven of the 29 competencies were rated as "highly important;" eight as of "medium importance;" and 14, or almost half, as "low importance." Competencies identified as highly important to Systems Engineering respondents are shown in Table 1.

Note that four of the seven competencies rated as highly important are professional or "soft skills" which apply across all career fields. Of the 25 analytic and technical management competencies specific to Systems Engineering, only three (or 12

percent) were rated as being highly important. Even though Lasley-Hunter states that the analysis "suggests that the SPRDE competency model captures the competencies most pertinent to the Systems Engineering," (Lasley-Hunter, 2011, p. 3) the fact that only 12 percent of the technical competencies were rated as "highly important" would imply otherwise. This result illustrates that the competencies represented in the DAU SPRDE Competency Model may not accurately reflect the *important* competencies needed in the SE workforce.

Table 1. DAU SPRDE Competencies Rated As Being "Highly Important" (After Lasley-Hunter, 2011, p. 36)

Analytical Unit of Competency	Competency 5: Requirements Analysis
	Competency 7: Implementation
	Competency 8: Integration
Professional Unit of Competency	Competency 24: Systems Engineering Leadership
	Competency 26: Communication
	Competency 27: Problem Solving
	Competency 29: Professional Ethics

Another interesting finding was the analysis of those competencies that were rated as being "N/A" or not applicable. This refers to, in most cases, competencies not needed on the job or, in fewer cases, competencies that the respondents were unaware of or unexposed to. Each of the 45 elements received N/A ratings ranging from 1 to 38 percent with the elements for Acquisition and Software Development receiving the highest percentages of N/A ratings (Lasley-Hunter, 2011, p. 42). This finding will come into play in the analysis of our third research objective when the DAU CL/POs are directly compared to the DAU SPRDE Competency Model to show which competencies the DAU curriculum addresses.

Finally, the results suggest that SE respondents have a proficiency level of intermediate to advanced for all competencies rated as highly important and intermediate proficiency in most other competencies (Lasley-Hunter, 2011, p. 4). Recall the study

referenced earlier by Kruger and Dunning that revealed how highly competent people tend to underestimate their level of competency while incompetent people tend to overestimate their level competency. This theory could have a bearing on the proficiency findings because they were based on self-assessment and therefore, possibly skewed.

In conclusion, the DAU SPRDE Competency Model was credibly developed and vetted. The resultant SPRDE Competency Assessment, completed in 2011, provides interesting insight into the SPRDE workforce; however, low participation leaves questions as to how well the results reflect the entire workforce. Both high education and high certification levels were exhibited, indicating that levels of certification might be adjusted or added to. Competency 23, Acquisition, received one of the highest "not needed on job" ratings and this will have an impact as we develop our analysis. Finally, because the proficiency ratings were based on self-assessment, they may not accurately reflect the proficiency of the workforce as a whole.

Next, we will look further into the development and characteristics of another competency model used extensively in this research, the NPS SE Competency Model.

C. NPS SE COMPETENCY MODEL

The research goals for the overall AT&L Competency Program are:

- AT&L Goal—1: Define the competencies required to deliver (needed) capabilities.
- AT&L Goal—2: Assess the workforce to identify current and future gaps (Lasley-Hunter, 2011, p. 8).

In response to these goals, the DASN (RDT&E) CHENG was not completely convinced by the CNA study that the DAU SPRDE Competency Model accurately reflected the skills needed by systems engineers in particular. Dr. Clifford A. Whitcomb, Chairman of the Systems Engineering Department at NPS, was tasked with leading a research team to develop a comprehensive approach to the design of a Naval Systems Engineering Competency Model. This primary nucleus of research has spurred several branches of associated student theses, including this project. Other related theses are noted in Chapter V.

The NPS Team found Holt's Pragmatic Guide to Competency to be a good reference and roadmap in the formulation of their model. In fact, one of the five models used in the NPS research, INCOSE, was evaluated in this guide. Holt is a proponent of combining appropriate pieces of existing frameworks into a new, unique framework that is applicable to a new field (Holt, 2011, p. 7–8). This is precisely what the NPS Team did. Initial development of the NPS SE Competency Model began with the identification of five previously existing SE competency models:

- Naval Undersea Warfare Center (NUWC), Newport SE Workforce Development Model
- International Council on Systems Engineering. United Kingdom Chapter (INCOSE UK) SE Competency Model
- National Aeronautics and Space Administration (NASA) SE Competency Model
- DAU SPRDE SE Competency Model
- Boeing SE Competency Model

Elements of these five models were categorized based on affinity, mapped to the 29 DAU competencies and duplicates were eliminated. The resultant model contained 2,151 KSAs in 31 competencies. 29 of these competencies were identical to the DAU SPRDE Model. The two additional competencies identified were "30.0 Systems Thinking" and "31.0 Interpersonal and Personal Characteristics."

As discussed previously in this research, a *good* competency model focuses on technical rather that "soft skills." The second version of the NPS SE Competency Model removed the professional skills and related KSAs from the framework. The intent was that these professional competencies would be applied to a separate, more generally applied competency model rather than one specifically for systems engineers. This update effectively removed 499 KSAs and six associated competencies. As a result, the second version of the NPS SE Competency Model contained 25 technical or core competencies and 1652 associated KSAs.

Competencies removed in Version 2 of the NPS SE Competency Model:

- 24.0 Systems Engineering Leadership
- 26.0 Communications

- 27.0 Problem Solving
- 28.0 Strategic Thinking
- 29.0 Professional Ethics
- 31.0 Individual and Interpersonal Characteristics

To address the application of these competencies across proficiency levels, each KSA was mapped to one of three specific career levels designated as SE-1 Entry Level, SE-2 Journey Level or SE-3 Expert Level. This was accomplished by first rating each KSA according to Bloom's Taxonomy of Educational Objectives which is discussed in more detail later in this section. Specifically, the NPS team used the version of Bloom's Taxonomy illustrated in the Graduate Reference Curriculum for Systems Engineering (GRCSE), which is shown in Table 2. While several interpretations and one revision of Bloom's Taxonomy exist, this GRCSE version was chosen because it was the most closely associated with Systems Engineering and the list of verbs was the most succinct and had the least repetition. This further strengthened the NPS Model with the inclusion of yet another valid source.

Bloom's Taxonomy provides hierarchical outcome categories or levels that range from simple to complex thought processes. Once the Bloom's level for each KSA was identified, the KSAs in each competency were divided into the three career levels by assigning the KSAs with lower Bloom's level ratings to the SE-1 Entry Level, the KSAs with intermediate Bloom's level ratings to SE-2 Journey Level and the KSAs with higher Bloom's level ratings to the SE-2 Expert Level.

Finally, the competencies were also categorized as to whether they would be developed by "Education and Training;" "On the Job Experience;" or "Professional Development." An example of this model showing Competency 1.0 Technical Basis for Cost is illustrated in Appendix B.

The third and current iteration of the NPS SE Competency Model was actually precipitated by the research addressed in this paper. As an initial part of the analysis for this project, 654 Course Learning/ Performance Objectives and Enabling Learning Objects for seven DAU SPRDE-SE Level III required courses were identified. These

CL/POs and ELOs were then defined as KSAs and added to the NPS Model as shown in Figure 6. They were also mapped to competencies in the NPS Model and to the GRCSE Bloom's levels.

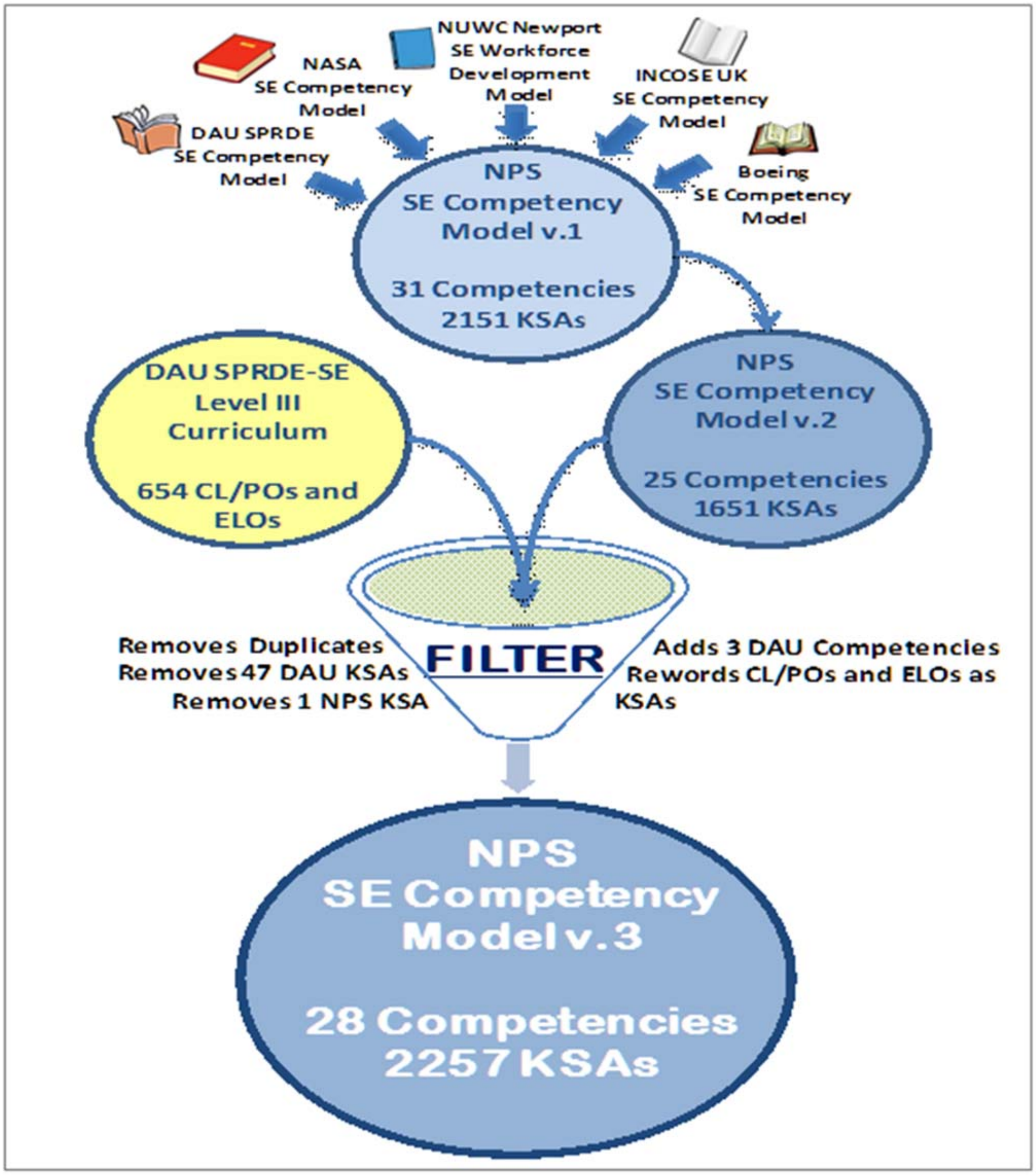

Figure 6. Evolution of NPS SE Competency Model

Incorporation of the DAU CL/POs and ELOs into the NPS SE Competency Model required considerable manipulation before the final third version emerged. First,

the new KSAs were reworded to incorporate the same Bloom's/ GRCSE verbs that are used in the rest of the NPS Model. Six duplicates were discovered and discarded. Next, KSAs associated with the professional competencies (Competencies 24.0, 26.0, 27.0, 28.0, 29.0 and 31.0) partitioned into a separate model from the SE model. The Team then agreed that 35. 0 (Domain Specialization) should be discarded as it didn't apply explicitly to systems engineering. That removed another 10 DAU KSAs as well as one KSA from version 2 of the NPS SE Competency Model. A total of 607 DAU KSAs and three competencies (32.0 Financial Management, 33.0 Contracting and 34.0 Facilities Engineering) were ultimately added to the NPS SE Competency Model.

The resultant and current version of the NPS SE Competency Model includes 2,257 KSAs in 28 competencies. Figure 6 show a graphic illustration of the evolution of the NPS SE Competency Model. version three (v.3) is used in the analysis of this research.

In conclusion, the NPS SE Competency Model has many traits of a *good* competency model. It is based on several sources and has evolved through many iterations. It applies across different proficiency levels and is easy to understand. Finally, the NPS SE Competency Model is based on technical skills rather than "soft" or professional skills. For these reasons, the NPS SE Competency Model is valid tool for the comparative analysis performed in this research.

D. BLOOM'S TAXONOMY OF EDUCATIONAL OBJECTIVES

This section will examine yet another tool used in the analysis of this research: Bloom's Taxonomy. The research objectives for this project involve a comparative analysis between the DAU SPRDE-SE curriculum and the NPS SE Competency Model as well as DAU SPRDE-SE curriculum and the SPRDE Competency Model. To implement these comparisons, a framework was needed to ensure that the research was comparing "apples with apples." DAU initially used Bloom's Taxonomy to provide the framework for course development. The NPS SE Competency Model also had used Bloom's Taxonomy to classify KSAs into career levels. Therefore, the popular and well

used Bloom’s Taxonomy was a logical choice. This section will look closer at the background of the Taxonomy, what it consists of, and why it is a good comparative framework.

Bloom’s Taxonomy of Educational Objectives is a classification of learning objectives originally developed to support communication between examiners. Although the Taxonomy takes Bloom’s name, it was a developed by a consortium of 34 educators who contributed by attending a series of conferences between 1949 and 1953. As one of the first classification frameworks for learning processes and educational goals, it is one of the most widely applied and most often cited references in education. “When an instructor desires to move a group of students through a learning process utilizing an organized framework, Bloom’s Taxonomy can prove helpful” (Forehand, 2005).

While Bloom’s Taxonomy has had a wide range of application, one of the most common uses has been “to classify curricular objectives and test items in order to show the breadth, or lack of breadth, of the objectives and items across the spectrum of categories” (Krathwohl, 2002). This applies precisely to our research objectives.

Bloom’s Taxonomy is a multi-dimensional framework consisting of three domains: Cognitive; Affective and Psychomotor. Loosely, these can be thought of as knowing/head; feeling/heart; and doing/hands. Each of these domains is comprised of several hierarchical levels. Each level requires prior assimilation of the knowledge and skills at next lower level. The idea of the Taxonomy was to motivate educators to use all three Domains to create a more comprehensive educational approach.

The Cognitive Domain was the first Domain developed, is the most widely used and best understood. Cognition is defined as a group of mental processes that range from remembering to learning, reasoning, problem solving and decision making. This domain is knowledge based and is highlighted in traditional education. It includes six levels: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation as shown in Table 2.

- Knowledge is the lowest of the cognitive levels and involves remembering, the recall of information. The analysis in Chapter III will support the fact that this cognitive level is common in education. Results

are typically right or wrong and opinion and judgment don't come into play. This type of outcome is straightforward, making it simpler to test and define.

- Comprehension is the understanding or interpretation of information.
- Application is using information to solve a problem; applying knowledge to a task.
- Analysis is the breaking down of information into parts and understanding how parts are related and organized.
- Synthesis is the combining of parts to create a new whole.
- Evaluation is judging the value or worth of information and ideas

Analysis of an educational curriculum typically shows a heavy emphasis on the cognitive domain and specifically, learning objectives that involve recall and memorization and that fall into the lower Bloom's categories. This is in direct conflict with most educational goals that favor the higher cognitive levels of understanding, applying, analyzing and creating. Systems engineering, in particular, is involved with analyzing and creating. Educators also tend to give even less attention to the affective domain which we will examine next.

The affective domain has to do with emotions, feelings and attitudes. Objectives describe growth in awareness, attitude, emotion, changes in interest, judgment and the development of appreciation. While most educators do not include the affective domain in their curriculum, and in fact this domain is completely absent from the DAU SPRDE curriculum, these outcomes are especially critical to the success of systems engineers. Systems engineers lead systems projects, negotiate outcomes with a diverse group of stakeholders, make value judgments and must have the ability to deliberately take the systems perspective (GRCSE, 2011, p. 95). These are all affective outcomes. Almost 29 percent of the NPS SE Competency Model's KSAs fall into this affective domain. The five levels of the affective domain are shown in Table 3.

Because Bloom's Taxonomy has been around for over 50 years, there have been many interpretations. Indeed a simple search of the Internet will yield dozens of slightly different versions which have been condensed, expanded, or use a wide range of language from simple and casual to complex and academic. As mentioned in the previous

section, we chose the GRCSE version of the Bloom’s model as a reference for our research. The reasons are three-fold. First, this version of Bloom’s Taxonomy was used to classify the KSAs in the NPS SE Competency Model. Using this version of Bloom’s to classify the DAU curriculum will allow for a more objective and direct comparison. Secondly, the GRCSE version of Bloom’s has the least redundant list of verbs or “outcome descriptors.” In some other versions of Bloom’s, the same verb is used as an outcome descriptor in several different Bloom’s levels. This leads to ambiguity.

Table 2. Bloom's Taxonomy of Educational Outcomes—Cognitive Domain (From GRCSE, 2011, p. 97–98)

Level	Sub-Level	Competency	Outcome Descriptors
Knowledge	• Knowledge of specifics • Knowledge of terminology • Knowledge of specific facts • Knowledge of ways and means of dealing with specifics (processes) • Knowledge of the universals and abstractions	Ability to remember previously learned material. Test observation and recall of information; i.e., "bring to mind the appropriate information;" e.g., dates, events, places, knowledge of major ideas, and mastery of subject matter.	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, and name (who, when, where, etc.).
Comprehension	• Translation • Interpretation • Extrapolation	Ability to understand information and ability to grasp meaning of material presented; e.g., translate knowledge into new context, interpret facts, compare, contrast, order, group, infer causes, predict consequences, etc.	Summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, and extend.
Application	• Application of methods and tools • Use of common techniques and best practices	Ability to use learned material in new and concrete situations; e.g., use information, methods, concepts, and theories to solve problems requiring the skills or knowledge presented.	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify,
Analysis	• Analysis of elements • Analysis of relationships • Analysis of organizational principles	Ability to decompose learned material into constituent parts in order to understand structure of the whole. This includes seeing patterns, organization of parts, recognition of hidden meanings, and obviously, identification of parts.	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, and infer.
Synthesis	• Production of a unique communication • Production of a plan, or proposed set of operations • Derivation of a set of abstract relations	Ability to put parts together to form a new whole. This involves the use of existing ideas to create new ones, generalizing from facts, relating knowledge from several areas, and predicting and drawing conclusions. It may also involve the adaptation of "general" solution principles to the embodiment of a specific problem.	Combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what-if analysis, compose, formulate, prepare, generalize, and rewrite.
Evaluation	• Judgements in terms of internal evidence • Judgments in terms of external criteria	Ability to pass judgment on value of material within a given context or purpose. This involves making comparisons and discriminating between ideas, assessing the value of theories, making choices based on reasoned arguments, verifying the value of evidence, and recognizing subjectivity.	award, choose, conclude, criticize, decide, defend, determine, dispute, evaluate, judge, justify, measure, compare, mark, rate, recommend, rule on, select, agree, interpret, explain, appraise, prioritize, opinion,

Table 3. Bloom’s Taxonomy of Educational Outcomes—Affective Domain (From GRCSE, 2011,pp. 99–100)

Level	Sub-Level	Competency	Outcome Descriptors
Receiving	• Awareness • Willingness to receive • Controlled or selected attention	The learner is aware of stimuli and is willing to attend to them. The learner may be able to control attention to the stimuli.	Focuses on and is aware of aesthetics, focuses on human values, is alert to desirable qualities, and shows careful attendance to input.
Responding	• Acquiescence in responding • Willingness to respond • Satisfaction in response	The learner makes a conscious response to the stimuli related to the aesthetic or quality. At this level the learner expresses an interest in the aesthetic things.	Demonstrates willing compliance and obedience to regulations and rules, seeks broad-based information to act upon, and accepts responsibility and expresses pleasure for own situation.
Valuing	• Acceptance of a value • Preference for a value • Commitment	The learner recognizes worth in the subject matter.	Continuing desire to achieve, assumes responsibility for, seeks to form a view on controversial matters, devotion to principles, and faith in effectiveness of reason.
Organization	• Conceptualizatin of a value • Organizationof a value system	The learner is able to organize a number of values into a system of values and can determine the inter-relationships of the values.	Identifies characteristics of an aesthetic, forms value-based judgments, and weighs alternative policies.
Characterization	• Generalilzed set • Characterization	The learner acts consistently with the systems of attitudes and values they have developed. The values and views are integrated into a coherent worldview.	Readiness to revise judgment in light of evidence, judges problems and issues on their merit (not recited positions), and develops a consistent philosophy of life.

Finally, GRCSE exists in a systems engineering context and examples of systems engineering outcomes are provided, which is helpful to our analysis.

Bloom’s Taxonomy is a popular, tried and true tool for categorizing educational outcomes. The DAU used the Taxonomy in the creation of their curriculum and the NPS SE Competency Model also used Bloom’s levels as a way of classifying KSAs into proficiency levels. It is a natural segue to use Bloom’s Taxonomy to compare these two models to each other.

E. OTHER MODELS AND SOURCES

In addition to the models and sources previously mentioned in this chapter, this Literature Review would not be complete without some reference to a few institutions that are pillars of the systems engineering world or basic reference in a defense acquisition context. This section will briefly review NDIA, INCOSE, GRCSE and the Defense Acquisition Guidebook and their impacts on this research.

As mentioned in Chapter I, an NDIA Systems Engineering Education and Training Working Group developed an original competency model with 29 competencies that was adopted by DAU and is referred to in this paper as the DAU SPRDE Competency Model. The INCOSE UK Competency Working Group is currently considering revising this framework specifically for INCOSE. The current INCOSE Competency Model is one of the five models that were initially integrated into the NPS SE Competency Model.

At a 6 May 2013 NDIA Education and Training Committee meeting, the Competency Working Group defined its vision as “An enhanced, individual and organization-usable INCOSE Competencies Framework based on demand with associated assessment instrument.” Objectives included evolving a “globally accepted and marketed standard competency framework,” that would

- be tailorable; useable by a variety of different organizations
- be useful for job candidate selection
- identify and mitigate gaps in training
- relate different competency models to each other.

This project has a great deal in common with the research being done at NPS with an important distinction. The INCOSE Competency Model is geared towards systems engineering *in general* while the NPS research focuses in on *naval acquisition* systems engineers. Eventually, there may be collaboration, but at this point, these projects are working independently.

The Graduate Reference Curriculum for Systems Engineering (GRCSE) along with the Systems Engineering Body of Knowledge (SeBOK) is part of the BKCASE

project and was mentioned earlier in this chapter as a reference for Bloom's Taxonomy. GRCSE is "the standard for what should be in a (graduate) systems engineering program for it to be properly called systems engineering" (Olwell, 2012). Part of the GRCSE framework was incorporated into the NPS SE Competency Model by use of its version of Bloom's Taxonomy. While GRCSE is a wonderful reference for the elements of graduate systems engineering education, the DAU curriculum's objectives are to provide the SPRDE workforce with learning needed on the job, rather than the curriculum needed for a graduate degree. The CNA SPRDE Competency assessment showed that over half the SPRDE workforce had a master's degree or higher. At some point, GRCSE could be used to compare the impact of these graduate degrees on the SPRDE workforce, however, that is well beyond the scope of this research.

In the review of different sources of information regarding systems engineering competencies and best practices, the Defense Acquisition Guidebook (DAG) warrants mention. The DAG is particularly relevant in this case because Chapter 4—Systems Engineering was just updated 8 May 2013, well beyond the halfway point of this research. The DAG is a product of DAU and there was concern that the CL/POs and ELOs used in our analysis had also been revised. As of this writing, however, no changes to the curriculum or objectives had been posted on the website or announced. The revisions in Chapter 4 simplified the structure by reducing the number of sections and primarily updated guidance to reflect current policy and DASD (SE) initiatives (ODASD [SE], 2013 May).

This section is a bit of a potpourri of other systems engineering models and sources of information that for one reason or another had a bearing on this research. The inclusion of this information contributes to the comprehensiveness and completes this Literature Review.

F. SUMMARY

This chapter has reviewed the various tools and sources that were used in the analysis of this research. Competency Models and Assessments have been discussed in terms of characteristics, uses, components and development. Two specific competency

models were then focused on. Both the DAU SPRDE Competency Model and the NPS SE Competency Model were evaluated in terms of development and characteristics and we also scrutinized the CNA assessment of the DAU SPRDE Competency Model. Bloom's taxonomy was reviewed and determined to be an appropriate framework for our comparative analysis and finally, we took a brief look at other systems engineering sources, models and curriculum.

Now that we have examined and evaluated the various components of our research, Chapter III will focus our data and analysis.

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III. DATA AND ANALYSIS

This chapter will examine the data and methodology used to answer each of the primary and secondary research questions. The two primary research questions involve a comparison of the DAU SPRDE-SE Level III curriculum and the NPS SE Competency Model. This data and analysis will be presented in Section A. The two secondary research questions require an internal analysis of the DAU SPRDE-SE curriculum to determine how well the course objectives are supported by the learning objectives and how well the DAU SPRDE-SE curriculum reflects its own competency model. The data and analysis pertaining to the secondary research questions will be presented in Section B. In each case, this research will explain how the data was obtained and its pertinence to this research. The framework used for comparison will be presented as well as the analysis of the data.

A. PRIMARY RESEARCH: RELATIONSHIP BETWEEN THE DAU SPRDE-SE LEVEL III CURRICULUM AND NPS SE COMPETENCY MODEL

The first two research questions involve a comparison between the training required by DAU to gain SPRDE-SE Level III Certification and the actual competencies needed to perform as a successful naval acquisition systems engineer. The data used to represent each of these entities will be examined individually and then applied to a framework for comparison.

The training required by the DAU SPRDE-SE program is identified as the CL/POs and ELOs of the courses required for certification. The competencies necessary for successful performance as a naval acquisition systems engineer have been identified by the NPS SE Competency Modeling Team as KSAs. These two models will provide the raw data for this project.

The data used to represent the DAU SPRDE-SE training requirements for Level III Certification were obtained directly from the DAU iCatalog. (Defense Acquisition iCatalog, 2013h) First, the courses required for SPRDE-SE Level III Certification were

determined. The Certification requirements are hierarchical and, therefore, all courses required for Level I and II are required for SPRDE-SE Level III DAWIA Certification. These ten courses are shown in Figure 7.

It is important to note that the data analyzed for this research applies to the training element of DAWIA Certification. SPRDE-SE Certification also requires the components of education and experience. This research focuses on the training element and does not address the impacts of education and experience on the SPRDE-SE workforce. Likewise, this research addresses only those training courses identified by DAU as part of the "Core Certification Standards required for DAWIA Certification." DAU also provides a "Core Plus Development Guide" which specifies "Desired training, education and experience" (DAU, 2013). Courses in the Core Plus Development Guide were not included in this research's analysis.

DAU SPRDE-SE Training Requirements for DAWIA Certification

Level I		
	ACQ 101	Fundamentals of Systems Acquisition
	SYS 101	Fundamentals of Systems Planning, Research, Development, and Engineering
	CLM 017	Risk Management
Level II		
	ACQ 201A	Intermediate Systems Acquisition, Part A
	ACQ 201B	Intermediate Systems Acquisition, Part B
	SYS 202	Intermediate Systems Planning, Research, Development, and Engineering, Part I
	SYS203	Intermediate Systems Planning, Research, Development, and Engineering, Part II
	CLE 003	Technical Reviews
Level III		
	SYS 302	Technical Leadership in Systems Engineering
	CLL 008	Designing for Supportability in DoD Systems

Figure 7. DAU SPRDE-SE Training Requirements

Once the required courses were identified, the objectives of these courses were identified. The Course Learning/ Performance Objectives (CL/POs) and the Enabling Learning Objectives (ELOs) were available from the DAU website for the seven acquisition (ACQ) and systems (SYS) courses, but not for the three continuing learning (CL) courses. Due to the lack of availability of course objectives for the CL courses and the time constraints of this research, the data for the three CL courses were not included in this analysis. The subject matter of these three courses is risk management, technical reviews, and designing for supportability in DoD systems. While these are relevant topics with regard to systems engineering competencies, the DAU estimates that these courses take only eight, four, and three hours respectively to complete. The other seven courses are estimated to take an average of 35 hours each. (DAU iCatalog, 2013h) With this in mind, it was deduced that the omission of these three courses would not substantially skew the results of the analysis. It should be noted that these CL courses were included in broader terms in the analysis of data pertaining to research question four, which will be discussed in Section B. From the seven ACQ and SYS courses, a total of 654 CL/POs and ELOs were identified and assembled for analysis.

Next, each CL/PO and ELO was categorized according to the GRCSE version of Bloom's Taxonomy as described in Chapter II. None of the data fell into the Affective Domain; hence, all CL/POs and ELOs were categorized into the Cognitive Domain as knowledge, comprehension, application, analysis, synthesis or evaluation. An example of the data is presented Appendix C.

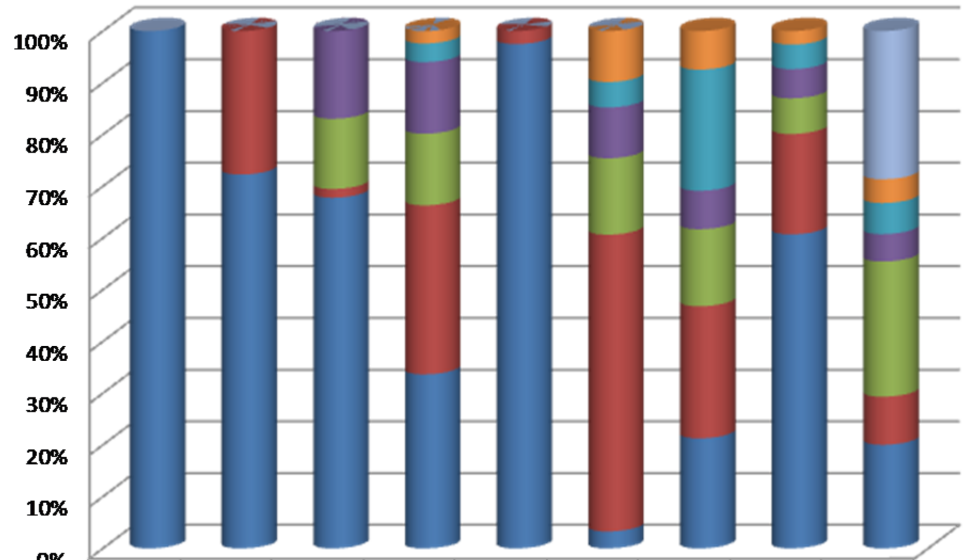
With the data for the DAU side of the comparison established, the second set of data needed for this comparison will be discussed. To represent the actual competencies needed to perform as a successful naval acquisition systems engineer, data from the NPS SE Competency Model Version 3 was used. The development and pertinence of this

model was discussed in detail in Chapter II, Section C. Version 3 of this Competency Model consists of 2,257 KSAs, which have been mapped to the same version of Bloom's Taxonomy (GRSCE) by the NPS SE Competency Model Team. It was recognized that the assignment of Bloom's levels is somewhat subjective. To reduce subjectivity, the same NPS SME that categorized the Bloom's levels for the NPS SE Competency Model KSAs was asked to review the assignment of Bloom's levels to the DAU SPRDE-SE curriculum. Revisions have been incorporated into the data.

With the data from DAU and the NPS SE Competency Model identified and mapped to Bloom's taxonomy, the analysis of this data with respect to the two Primary Research Questions will be examined.

1. Comparison of Cognitive Levels of DAU SPRDE-SE Level III Training Requirements with the NPS SE Competency Model

Primary Research Question number 1 asks for a comparison of the DAU SPRDE-SE training requirements for Certification and the competencies needed to perform as a proficient naval systems engineer. To answer this research question, the cognitive levels of the 112 DAU SPRDE-SE Level III CL/POs and 542 ELOs were compared to those of the 2,257 KSAs in the NPS SE Competency Model. Percentages of each cognitive level were calculated for each DAU course, separately and collectively, to compare directly with the percentages of each cognitive level found in the NPS Model. The results are shown in Figure 8.



	ACQ101	SYS101	ACQ201A	ACQ201B	SYS202	SYS203	SYS302	SPRDE-SE Totals	NPS SE COMP MOD
affective	0	0	0	0	0	0	0	0	29%
evaluation	0%	0%	0%	2%	0%	10%	7%	3%	5%
synthesis	0%	0%	0%	3%	0%	5%	23%	5%	6%
analysis	0%	0%	17%	13%	0%	10%	7%	6%	5%
application	0%	0%	14%	13%	0%	15%	15%	7%	26%
comprehension	0%	28%	2%	31%	3%	57%	26%	19%	9%
knowledge	100%	72%	68%	32%	98%	3%	21%	61%	20%

Figure 8. Cognitive Levels of DAU SPRDE-SE Level III Curriculum and NPS SE Competency Model

2. Direct Comparison between DAU SPRDE-SE CL/POs and ELOs and the NPS Competency Model KSAs

Primary Research Question number 2 asks for a direct comparison of the DAU SPRDE-SE Level III curriculum with the knowledge, skills and abilities identified by the NPS SE Competency Model to find the overlaps and gaps between the required training and what is currently being provided by DAU. Because Version 3 of the NPS model absorbed a large percentage of the DAU curriculum, as explained in Chapter II Section C, this comparison is very straightforward.

Of the 2,257 KSAs in the NPS SE Competency Model, 613 were contributed directly from the DAU curriculum. These 613 newly defined KSAs include six duplicates and 607 additions to version 2 of the NPS Model. The other 41 CL/POs or ELOs fall into one of the seven competencies that were set aside from the NPS SE Competency Model. The analysis of this data is shown in Figure 9.

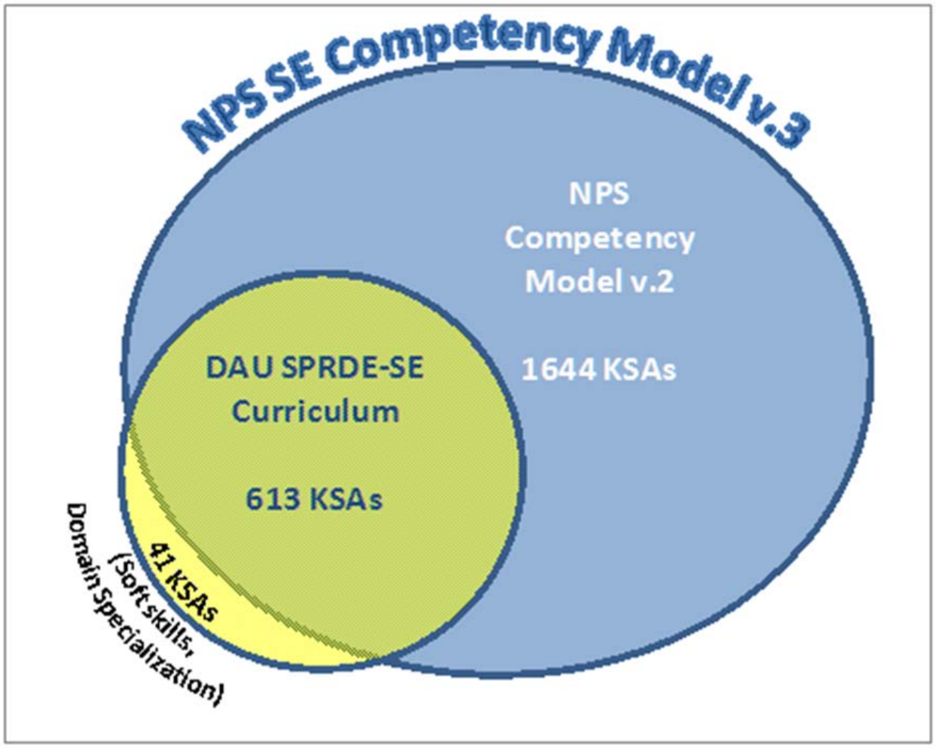


Figure 9. NPS SE Competency Model and DAU SPRDE-SE Curriculum

B. SECONDARY RESEARCH: INTERNAL DAU SPRDE-SE CURRICULUM ANALYSIS

The secondary research questions involve an *internal* analysis of the DAU SPRDE-SE curriculum rather than a comparison to another model. This Section will examine the data and analysis used to answer the secondary research questions.

1. Correlation between DAU SPRDE-SE CL/POs and ELOs

Secondary Research Question number 1 requires examination of the DAU SPRDE-SE Enabling Learning Objectives (ELOs) to determine the extent to which they

support and reflect the Course Learning/ Performance Objectives. While data for the primary research questions was being analyzed, it became apparent that some ELOs mapped to a different Bloom's cognitive level than did the overarching CL/PO. This research question addresses the extent to which this inconsistency exists.

To address this research question, the Bloom's levels of ELOs were analyzed with respect to their overarching CL/PO. First, the CL/POs were simply divided into two categories: those with consistent ELOs and those with inconsistent ELOs. Next, the CL/POs with inconsistent underlying ELOs were further subdivided into more specific categories. These categories are based on whether those inconsistencies were result of higher or lower Bloom's levels. The analysis shown in Figure 10 shows the total number and percentages of CL/POs with the following types of inconsistencies:

- CL/POs with all lower cognitive level ELOs
- CL/POs with equal or lower cognitive level ELOs
- CL/POs with equal or higher cognitive level ELOs
- CL/POs with all higher cognitive level ELOs
- CL/POs with both higher and lower cognitive level ELOs

The impact of each of these inconsistencies will be addressed in Chapter VI.

SPRDE-SE Course Learning/ Performance Objectives (CL/POs) relative to associated Enabling Learning Objectives (ELOs)

DAU COURSE	Total CL/POs	CL/POs with consistent ELOs	CL/POs with in-consistent ELOs	CL/POs with lower cognitive level ELOs	CL/POs with equal or lower cognitive level ELOs	CL/POs with equal or higher cognitive level ELOs	CL/POs with all higher cognitive level ELOs	CL/POs with both higher and lower cognitive level ELOs
ACQ101	23	23	0					
SYS101	21	5	16		2	14		
ACQ201A	6	1	5		1	1	1	2
ACQ201B	18	0	18	9	7			2
SYS202	8	7	1			1		
SYS203	18	8	10	1	3	4	1	1
SYS302	18	2	16	3	7	2	1	3
TOTALS	112	46	66	13	20	22	3	8
Percent of Total:		41%	59%	12%	18%	20%	3%	7%

Figure 10. Correlation between DAU SPRDE-SE CL/POs and ELOs

2. Correlation between DAU SPRDE-SE Level III Curriculum and the DAU Competency Model

Secondary Research Question #2 involves a comparison of the DAU SPRDE-SE Level III CL/POs and the competency model adopted by DAU. Analysis of this data will show the extent to which the courses required for SPRDE-SE Level III Certification provide the training needed by systems engineers as defined by DAUs own competency model.

For this comparison, the original intent was to map the 112 CL/POs to the 29 competencies in the DAU model. However, to achieve accurate mapping, it was necessary to also include Competencies 30.0—35.0 as identified by the NPS SE Competency Model. These six competencies are not found in the DAU Competency Model. The 112 CL/POs identified in the seven courses used for prior analysis were mapped to these 35 competencies. Also mapped were the three CL courses for which detailed information was not available. Each of the three CL courses was represented as one CL/PO for a total of 115 CL/POs. The analysis of this data is shown in Figure 11.

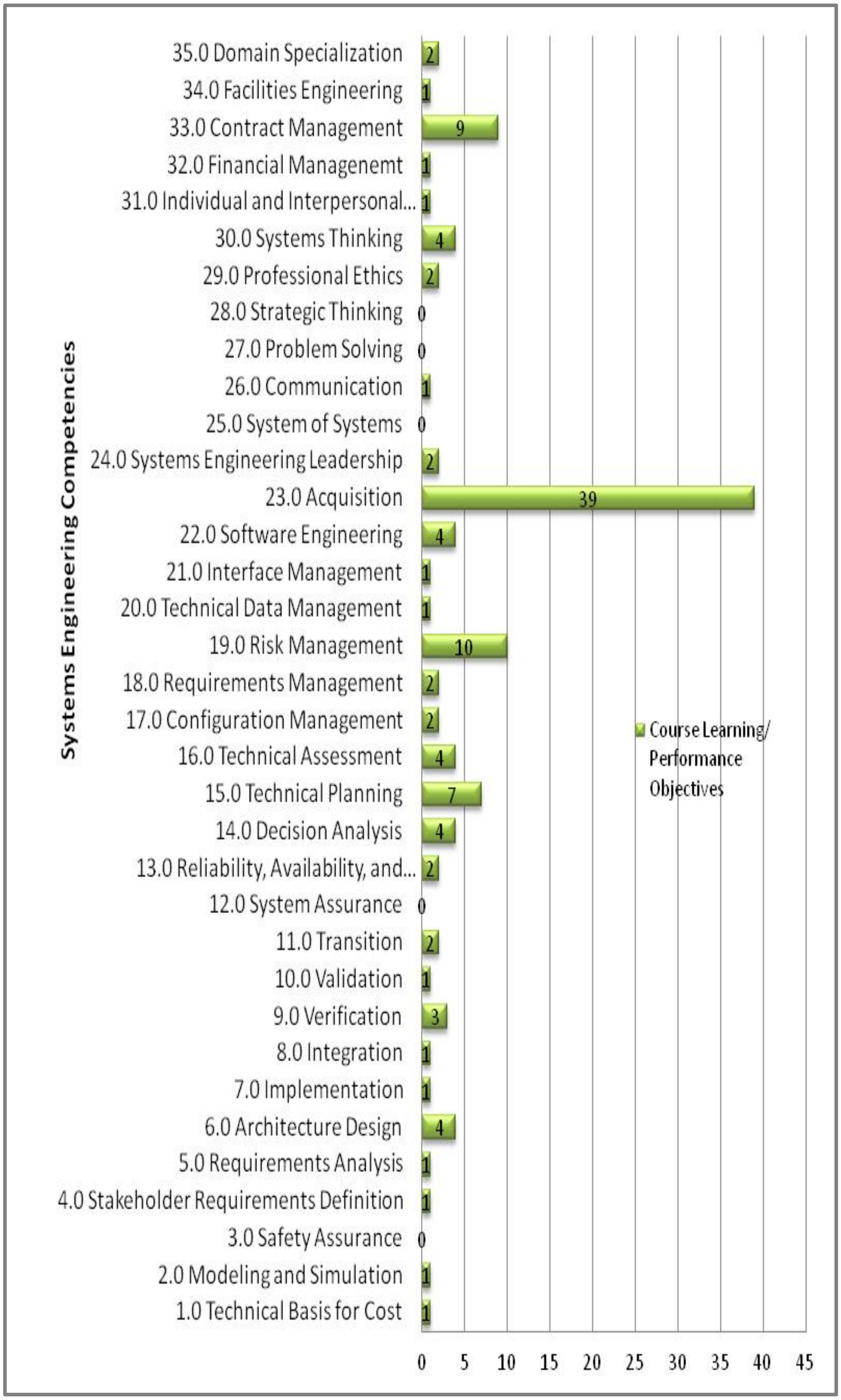


Figure 11. Number of DAU SPRDE-SE CL/POs in each Systems Engineering Competency

C. SUMMARY

This chapter has presented the data used and the methodology applied to address the four objectives of this research. It has also discussed the scope of the data used and how that data were developed.

The primary research questions involve data relating to the DAU SPRDE-SE curriculum and the NPS SE Competency Model. These data were analyzed based on cognitive level and by direct comparison. The secondary research questions focus specifically on data reflecting the DAU SPRDE-SE curriculum to provide an analysis of how well the DAU SPRDE-SE learning objectives support the course objectives and to what extent the SPRDE-SE curriculum reflects the competencies identified in the DAU SPRDE Competency Model.

Chapter IV will discuss the results of this analysis with regard to each of the four research questions.

IV. FINDINGS/RESULTS

Chapter III provided the data and analysis needed to answer each of the four research questions. This chapter will examine and discuss that data and analysis to draw conclusions and answer the four research questions. Findings that were not obvious at the start of this research but that emerged through the research process will also be discussed.

A. PRIMARY RESEARCH FINDINGS

To answer the primary research questions, data drawn directly from the DAU iCatalog were analyzed and compared with data provided by the NPS SE Competency Model. This section will discuss that data and their implications, draw conclusions, and provide answers to the primary research questions.

1. Findings Related to the Comparison of Cognitive Levels of DAU SPRDE-SE Level III Training Requirements and the NPS SE Competency Model

Primary Research Question number 1 asks to what degree the DAU SPRDE-SE training requirements for DAWIA Certification reflect the competencies needed to perform as a proficient systems engineer in the naval acquisition enterprise as identified by the NPS SE Competency Model. Figure 8 shows a comparison of the cognitive levels of these two models.

The first subjective impression of Figure 8, with regard to the DAU courses, is that there is a lot of blue, which represents knowledge. In fact, 61 percent of the DAU SPRDE-SE CL/POs and ELOs fall into the knowledge category and 80 percent of *all* DAU SPRDE-SE CL/POs and ELOs are in the lower third of the Bloom's Cognitive Domain.

Two of the seven courses analyzed are particularly focused on knowledge. ACQ 101, the first course in DAU SPRDE-SE Level I, focuses 100 percent on knowledge, which is simple retention. Because ACQ 101 is an introductory course, this is understandable. What is notable, however, is that 98 percent of the objectives for SYS

202, a Level II course, only require knowledge. At the second level of a certification program, higher cognitive levels, such as analysis or application, would be expected.

As for the higher two-thirds of the cognitive domain, no more than seven percent of all SPRDE-SE CL/POs and ELOs fall into any one of the four higher cognitive levels. Only 20 percent of the entire DAU SPRDE Level III training program falls into the higher two-thirds of the cognitive domain. Finally, none of the SPRDE-SE course or learning objectives applied to the affective domain which reflects such skills as engagement, the ability to lead systems projects, negotiate outcomes, communicate with diverse groups, and make value judgments. Mastery of these types of abilities is particularly crucial for systems engineers and is part of what distinguishes them from other engineers.

In contrast, it was found that only 29 percent of the KSAs identified in the NPS SE Competency Model require the lower third cognitive levels of knowledge and comprehension. The need for application abilities is strongly represented by 26 percent of the KSAs. Also significant is that 29 percent of all KSAs in the NPS SE Competency Model fall into the affective domain.

All these comparisons and findings illustrate differences between the SPRDE-SE curriculum and the NPS SE Competency Model KSAs. There are, however, similarities as well. The data shows that the highest three cognitive levels (analysis, synthesis and evaluation) are similarly represented in both models. These three highest cognitive levels account for 14 and 16 percent of the SPRDE-SE learning objectives and NPS KSAs respectively.

These findings show that the majority of the learning objectives of the SPRDE-SE Level III curriculum require substantially lower cognitive levels of thinking than do the actual competencies required to perform as a proficient systems engineer in the naval acquisition enterprise as identified by the NPS SE Competency Model. The SPRDE-SE curriculum specifically shows a gap or lack of development of skills pertaining to the *application* of knowledge and as well as skills falling into the affective domain.

The data also shows an overlap between the models. The highest three cognitive levels of analysis, synthesis and evaluation are similarly required in both the SPRDE-SE curriculum and the NPS SE Competency Model. These highest three cognitive levels are represented with 14 and 16 percent, respectively, of the two models.

2. Findings related to the Direct Comparison between DAU SPRDE-SE CL/POs and ELOs and the NPS Competency Model KSAs

Primary Research Question number 2 asks for the similarities, differences, gaps and overlaps between DAU SPRDE-SE curriculum and NPS SE Competency Model KSAs. Some important similarities, differences, gaps and overlaps in cognitive levels were identified in the findings developed to answer the first research question. Further analysis was done, however, to *directly* compare the CL/POs and ELOs from the SPRDE-SE curriculum to the KSAs in the NPS SE Competency Model. This comparison will show the difference between the KSAs needed by a proficient naval acquisition systems engineer and the training provided by DAU.

The data, illustrated in Figure 9, shows a total of 2,257 KSAs in the NPS SE Competency Model, v.3. Of these, 613, or only 27 percent of the NPS Model, are addressed by the DAU curriculum. Conversely, these 613 KSAs represent 94 percent of the DAU SPRDE-SE curriculum. The other 41 CL/POs and ELOs, or 6 percent of the DAU SPRDE-SE curriculum, applies to either soft skills or Domain Specialization and were not included in the current version of the NPS SE Competency Model. Recall that professional skills are recognized as being important for systems engineers and that these competencies will likely be incorporated in the NPS SE Competency Model or a sister model, as it continues to develop. This will result in the inclusion of an even higher percentage of the DAU SPRDE-SE curriculum.

These findings show that a 27 percent overlap and a 73 percent gap exists in the training of the knowledge, skills and abilities needed to perform as a proficient naval acquisition systems engineer. The implications are both good and bad. The good news is that the DAU is providing 27 percent of what systems engineers need and that is a good

start. The challenge will be in determining where naval acquisition systems engineers are getting the other 73 percent of the knowledge, skills and abilities they need.

This section has determined the extent to which the DAU SPRDE-SE training requirements reflect the competencies needed to perform as a proficient systems engineer in the naval acquisition enterprise. Similarities, differences, gaps and overlaps between DAU SPRDE-SE training curriculum and NPS SE Competency Model KSAs have been identified and analyzed. Next, findings pertaining to the secondary research questions will be discussed.

B. SECONDARY RESEARCH FINDINGS

The secondary research questions were developed to provide insight into the strength and consistency of the DAU training curriculum and to determine how well it reflects the DAU SPRDE Competency Model. This analysis is in contrast to the primary research objectives which compared the SPRDE-SE curriculum to the NPS SE Competency Model. The findings related to this internal analysis of the DAU SPRDE curriculum and competencies will be presented in this section.

1. Findings related to the Correlation between DAU SPRDE-SE CL/POs and ELOs

Secondary Research Question #1 asks for the extent to which the DAU SPRDE-SE Enabling Learning Objectives support and relate to the overarching Course Learning/ Performance Objectives. These findings will help to determine whether the actual objectives of the DAU SPRDE-SE training are being provided for through the curriculum and are illustrated in Figure 10.

The initial data analysis showed that 59 percent of CL/POs were supported by ELOs with inconsistent cognitive levels. This is one reason why CL/POs and ELOs were given equal weight as KSAs in the NPS SE Competency Model. This finding, in and of itself, is not enough to determine impact on the curriculum. The specific characteristics of the inconsistencies were analyzed and these have important implications. This analysis further divided the 66 inconsistently supported CL/POs into five categories of various types of inconsistency.

The first category of inconsistency examined is CL/POs completely supported by ELOs that required lower cognitive levels. This category is the most pertinent to this research and represents 12 percent of all SPRDE-SE CL/POs. A specific example can be seen in the data for ACQ 201B, CL/PO 3.0 shown in Appendix C. In these cases, all the underlying ELOs require lower cognitive levels, such as the ability to identify or select information, than those of the overarching CL/PO, which may require synthesis or evaluation. This category is particularly significant in that it is difficult to understand how the student is expected to progress from the lower cognitive level ELOs to achieve the higher cognitive level CL/POs.

The other four categories all include ELOs with cognitive levels that are equal to or higher than the overarching CL/PO. While these inconsistencies may warrant further research, the inconsistencies themselves do not present issues. Because the cognitive levels are hierarchical, it is easy to understand how a student who has achieved a higher cognitive level ELO could then apply that to achieve a lower cognitive level CL/PO. Likewise, ELOs requiring cognitive levels lower than and equal to the CL/PO could be explained as developmental.

These findings conclude that 59 percent of the overarching CL/POs are comprised of inconsistent ELOs and that at least 12 percent of the CL/POs are not sufficiently supported by the underlying ELOs. It would follow that further research into the effectiveness and validity of the DAU SPRDE-SE curriculum and whether goals and objectives are being met may be warranted.

2. Findings related to the Correlation between DAU SPRDE-SE CL/POs and the DAU SPRDE Competency Model

Secondary Research Question number 2 focuses on the extent to which the DAU SPRDE-SE Course Learning/ Performance Objectives reflect the DAU Competency Model. Recall that the three CL courses not included in the data for the primary research were, in fact, included in this analysis, each categorized as one CL/PO. This inclusion has resulted in a more comprehensive set of data for this research question.

When the 115 CL/POs were mapped to the 29 competencies represented in the SPRDE Competency Model, various interesting results emerged. This section will examine the degree to which there is a link between the DAU SPRDE-SE curriculum and the associated DAU SPRDE Competency Model. A strong link suggests continuity and strength in the development of the SPRDE program whereas a weak link implies that the curriculum does not support the identified competencies. The analysis of this data is shown in Figure 11. These findings will be discussed individually and a resultant comprehensive conclusion will be drawn.

First, 5 of the 29 competencies had no associated CL/POs. That means that DAU provides no training for 17 percent of the competencies identified in the DAU SPRDE Competency Model. These competencies are Safety Assurance, System Assurance, System of Systems, Problem Solving, and Strategic Thinking. This does not show evidence of a strong link between the curriculum and the competency model. To take this point one step further, 15 competencies, or over half, were supported by zero or one CL/PO. This would strongly demonstrate that the competencies in the model are not being addressed by the DAU SPRDE training curriculum.

Secondly, 18 CL/POs, or 15 percent of all CL/POs in the DAU SPRDE-SE curriculum, mapped to six competencies *not identified* in the DAU SPRDE Competency Model. Again, this does not suggest a strong link between the SPRDE-SE curriculum and the SPRDE Competency Model. These six competencies are Financial Management, Contract Management, Facilities Engineering, Individual and Interpersonal Skills, Systems Thinking, and Domain Specialization. With the exception of Domain Specialization and Individual and Interpersonal Skills (a soft skill), it has been determined that the other four competencies are important for naval acquisition systems engineers. This is evidenced by their inclusion in the NPS SE Competency Model. The implication of this finding is that these competencies should be added to the DAU Competency Model as well.

Next, Competency 23.0 Acquisition, accounted for the highest number of CL/POs being supported by 39, or 34 percent, of all SPRDE-SE CLC/POs. This finding shows that the DAU SPRDE-SE curriculum is focused on the DoD acquisition environment as

opposed to a more generic systems engineering setting. This concentration, however, could be to the detriment of training for other important competencies and does not necessarily demonstrate a strong link between the DAU SPRDE-SE curriculum and the SPRDE Competency Model. An associated finding is that this strength in acquisition training added viability to the NPS SE Competency Model when the DAU SPRDE-SE curriculum was incorporated in its third version.

The competencies with the next highest number of supporting CL/POs are; Risk Management with 10, Contract Management with nine, and Technical Planning with seven. All other competencies had no more than four supporting CL/POs.

As for the rest of the competencies in the model, 23 competencies were each addressed by one to 10 CL/POs. These 23 competencies accounted for 58, or 50 percent, of all SPRDE-SE CL/POs. Of these 23 competencies, 13 were supported by only one CL/PO.

To summarize, of the 115 SPRDE-SE CL/POs:

- 50 percent applied to 23 of the 29 competencies identified in the SPRDE-SE Competency Model.
- 34 percent applied to one competency
- 18 percent applied to six competencies *outside* the SPRDE Model
- 0 percent applied to five competencies

While these findings are all interesting, only the last one directly relates to the secondary research question. The fact that five of the 29 competencies are not addressed by any of the CL/POs conversely means that the DAU SPRDE-SE CL/POs only reflect 83 percent of the competencies in their own model.

This section has presented the findings related to the secondary research questions. Specifically, it has determined that 12 percent of the DAU Course Learning / Performance Objectives are not supported cognitively by the associated Enabling Learning Objectives and that the DAU curriculum only reflects 83 percent of the competencies in the DAU SPRDE-SE Competency Model. Next, findings other than those related to the primary and secondary research questions will be discussed.

C. OTHER FINDINGS

In the course of the exploring the background of this research, developing the data and analysis; and discovering the findings, two other related findings have emerged.

First, the SPRDE-SE career field is extremely broad. As referenced in Chapter I, 28.1 percent of the entire DAW is classified as SPRDE. Of that, 92 percent is SPRDE-SE. This career field currently includes computer engineers, structural engineers, electrical engineers, mechanical designers, software engineers, human factors engineers, reliability engineers and others. All of these professionals are not systems engineers. The data would suggest that this career field requires finer definition.

Another interesting finding is that contracting is a vital competency for SEs. This competency is part of what differentiates the DAU and NPS competency models from other, more mainstream SE models such as INCOSE. It was found that contracting is the third most highly addressed competency in the DAU SPRDE-SE curriculum, accounting for 8 percent of all CL/POs. Only acquisition and risk management were addressed with a more concentrated level of curriculum. The third version of the NPS SE Competency Model has incorporated contracting as one of the 28 competencies. Because the DAU SPRDE-SE curriculum reflects such a high percentage of contracting course objectives, it would seem plausible that this competency be added to their model as well.

D. SUMMARY

This chapter has discussed the findings resulting from the previously presented data with regard to the four research questions. Two other findings that emerged in the course of this research were also discussed.

It was found that the DAU SPRDE-SE curriculum requires a much lower cognitive level that the competencies actually required to perform as a proficient naval acquisition systems engineer and addresses no thought processes in the affective domain. The research also discovered that the DAU SPRDE-SE curriculum covers 27 percent of the required KSAs. Another finding is that less than half of the DAU SPRDE-SE

curriculum CL/POs are consistently supported by their underlying ELOs. Finally, the DAU SPRDE-SE curriculum does not accurately reflect the DAU SPRDE Competency Model.

The next chapter will draw conclusions from these findings, summarize this research and provide recommendations for further study.

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V. CONCLUSIONS, RECOMMENDATIONS, SUMMARY AND AREAS FOR FURTHER RESEARCH

A. CONCLUSIONS AND RECOMENDATIONS

The findings of this research lead to several conclusions about the DAU SPRDE-SE training program, required curriculum and competency model.

First, this research has established that a gap exists in the training for naval acquisition systems engineers with relation to cognitive abilities and educational outcomes. Naval acquisition systems engineers need training requiring higher cognitive levels than the training provided by the DAU SPRDE-SE certification program. A full 80 percent of the of the DAU SPRDE-SE certification curriculum requires only the lower cognitive levels of knowledge and comprehension. Specifically lacking is training pertaining to the application of knowledge as well as training with respect to those abilities developed by the affective domain. Affective outcomes, such as developing consensus, communication across professional cultures, and exercising judgment are particularly essential for systems engineers. These higher levels of educational outcomes are not addressed sufficiently by the DAU SPRDE-SE certification curriculum. To provide comprehensive training for DON systems engineers, a determination must be made as to where and how these higher levels of thinking will be developed.

Secondly, DAU has developed a SPRDE-SE training curriculum to satisfy DAWIA requirements. This training does not define or describe what naval acquisition systems engineers are or what they need to know to excel. The DAU SPRDE-SE training curriculum required for DAWIA certification addresses only 27 percent of the knowledge, skills and abilities required by naval acquisition systems engineers. While this classifies as a *component* of comprehensive training, it also highlights the need to

identify the source for the other 73 percent. While DAU is providing the AWF with DAWIA certification, this training is not comprehensively sufficient to address proficiency achievement for naval acquisition systems engineers.

Thirdly, more research is needed to determine whether the information taught in the DAU SPRDE-SE curriculum reflects the desired outcomes. This research discovered that almost 60 percent of the overarching course objectives were supported with inconsistent learning objectives. This could be due to an incomplete listing or misinterpretation of the learning objectives. However, this research concludes that confirmation is needed that the 27 percent of needed training referenced in the preceding paragraph is actually being achieved and not just wishful thinking.

Another conclusion drawn from this research is that the DAU SPRDE-SE certification curriculum is not aligned with the DAU SPRDE Competency Model. The training curriculum fails to address five of the 29 competencies in any way, however it does address six competencies not present in the SPRDE Model. Most of these competencies have been identified by the NPS SE Competency Model as being valid for inclusion. In conclusion, the link between the DAU SPRDE-SE training curriculum and the DAU SPRDE Competency Model is weak. Closer alignment of the DAU curriculum and SE competencies could result in a stronger overall training program.

Finally, to properly focus training on this highly specialized workforce, the systems engineering career field needs to be more accurately defined. Currently, the SPRDE-SE career field is too broad and includes many other types of systems engineers. Systems engineering heavily influences the outcomes of acquisition programs. Attention to the accurate training of this workforce is imperative to the success of major acquisition programs.

B. SUMMARY

This research provides an analysis of the training requirements and competencies for naval acquisition systems engineers. The DAU SPRDE-SE training curriculum required for DAWIA certification has been compared and contrasted in different ways, both externally with the NPS SE Competency Model, and internally with DAU's own competency model. The strength of the curriculum itself has also been examined.

Although the DAU SPRDE certifications represent the assimilation of some systems engineering capabilities, there is a large gap between the training required for SPRDE certification and the competencies required to perform successfully as a naval systems engineer. This research has also shown that the DAU SPRDE-SE curriculum does not accurately reflect the 29 competencies identified in the DAU SPRDE Competency Model.

C. AREAS FOR FURTHER RESEARCH

The development of this research has brought to light several new questions and areas for further investigation.

The conclusions suggest that further investigation is needed into the SPRDE-SE certification curriculum to determine whether the information taught in the DAU SPRDE-SE courses actually reflects the desired outcomes. Also, a closer look into the DAU Competency Model is warranted to see what affects it does or doesn't have on the SPRDE-SE learning objectives.

The NPS SE Competency Model is also fertile ground for further research. This model is in its third iteration and no doubt further versions will be developed. Intention exists to incorporate the professional competencies that were set aside in the second version. It has been demonstrated that these competencies, while not unique to systems engineers, are crucial for systems engineers. These competencies could be recognized as a secondary competency model or another completely separate competency model that would apply to a wider range of career fields.

The NPS SE Competency Model is developing as a universal competency model that can be tailored or customized for different organizations/ agencies. One associated body of research is currently being conducted at SPAWAR using the NPS SE model as a framework. As this use of the NPS SE Competency model is developed, its applications will grow exponentially. This application could be particularly useful for agencies outside the DoD, such as the U.S. Coast Guard (DHS), who are not under the umbrella of DAU and require the development of their own training programs.

Finally, this research has established that a gap exists in the training needed by naval acquisition systems engineers for their development. This leads directly to the question of where and how the SPRDE workforce can obtain the training needed to fill this gap in knowledge, skills and abilities not addressed in the DAU SPRDE training program. While this research has focused on training, competencies are also developed through formal education and work experience. The impact of education and work experience on the gap in training identified by this research is highly relevant for further study.

APPENDIX A. DAU SPRDE COMPETENCY MODEL

Table 4. SPRDE-SE/PSE Competency Model (After Lasley-Hunter, 2011, pp. 83–87)

Units of Competence	Competencies	Competency Elements
Analytical	**Competency 1.** Technical Basis for Cost	**Element 1.** Provide technical basis for comprehensive cost estimates and program budgets that reflect program phase requirements and best practices using knowledge of cost drivers, risk factors, and historical documentation (e.g. hardware, operational software, lab/support software).
	Competency 2. Modeling and Simulation	**Element 2.** Develop, use, and/or interpret modeling or simulation in support of systems acquisition throughout the entire Defense Acquisition Management System (changed from framework). Understand and use M&S from other domains in support of systems acquisition.
	Competency 3. Safety Assurance (changed from Safety Analysis)	**Element 3.** Review Safety Assurance artifacts to if requirements and constraints needed to meet SE design goals for: Safe For Intended Use (SFIU), war-fighter survivability, user safety, software safety, environmental safety, Programmatic Environmental, Safety and Health Evaluations (PESHE), and/or Critical Safety applications were met.
	Competency 4. Stakeholder Requirements Definition (Requirements Development)	**Element 4**. Elicit inputs from relevant stakeholders translate the inputs into technical requirements.
	Competency 5. Requirements (Logical Analysis)	**Element 5.** Define and refine system, subsystem, lower-level functional and performance requirements and interfaces to facilitate the Architecture Design proccess.
	Competency 6. Architecture Design (Design Solution)	**Element 6.**Identify the full set of decomposed and overall design considerations, across the full system life-cycle and in all operating environments, that should be addressed during systems engineering in order to obtain the "best value "for the user.
		Element 7. Track and manage design considerations (boundaries, interfaces, standards, available production process capabilities, performance and behavior characteristics) to ensure they are properly addressed in the technical baselines.
		Element 8. Translate outputs from the Stakeholder Requirements Definition and Requirements Analysis processes to generate a final design or physical architecture, using the Architecture Design process, including reviews of alternative designs.
		Element 9. Conduct walkthroughs with stakeholders ensure that requirements will be met and will deliver planned systems results under all combination of design

Units of Competence	Competencies	Competency Elements
Analytical	**Competency 7.** Implementation	**Element 10.** Fabricate hardware/code software to realize system elements.
	Competency 8. Integration	**Element 11.** Use the Integration process to ensure the lower-level system elements are incorporated into higher-level system elements and that the final system is incorporated into its operational environment.
	Competency 9. Verification	**Element 12.** Design and implement a testing process to compare a system against required system capabilities, to link Modeling and Simulation (M&S), Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) together, in order to document system capabilities, limitations, and risks.
		Element 13. Assess the "Did you build it right?" question question in the Verification Process by determining if system elements meet design specifications as defined in the functional, allocated, and product baselines using reviews of test plans, among other inputs.
	Competency 10. Validation	**Element 14.** Assess the "Did you build the right thing?"question in the Validation Process, by determining whether there was a satisfactory performance of systems within their intended operational environment, using validation metrics.
	Competency 11. Transition	**Element 15.** Move the system elements to the next Level in the physical architecture or move the end item to the user for use.
	Competency 12. System Assurance	**Element 16.** Apply and execute the appropriate systems engineering, software assurance, and certification related policies, principles, and practices across all levels and phases of an acquisition program to increase the level of confidence that a system functions as intended, is free from exploitable vulnerabilities, and protects critical program information.
	Competency 13. Reliability, Availability & Maintainability (RAM)	**Element 17.** Determine how best to integrate and phase RAM into the systems engineering processes across the design.
		Element 18. Evaluate the RAM of systems, including the following: Maintenance Engineering/ Sustaining Engineering review and assessment; considerations of different use environments, operators, and maintainers; and the monitoring of performance versus predictions of performance.

Units of Competence	Competencies	Competency Elements
Technical Management	**Competency 14.** Decision Analysis	**Element 19.** Develop and/or use a Decision Analysis process to incorporate factors such as operational environment, mission performance, cost, and design consid- erations into decision-making.
	Competency 15. Technical Planning	**Element 20.** Use Technical Planning to ensure technical and technical management processes, technical reviews, and the program office's organization are documented in the Systems Engineering Plan and applied throughout a system's acquisition lifecycle.
	Competency 16. Technical Assessment	**Element 21.** Develop and/or use Technical Assessment metrics (i.e., Technical Performance Measures, Measures of Effectiveness, requirements compliance, and risk assessments) to measure technical progress, review life-cycle costs, and assess the effectiveness of plans and requirements.
	Competency 17. Configuration Management	**Element 22.** Use a Configuration Management process to track configuration changes and ensure that a product or system's attributes are consistent with its requirements, evolving technical baseline over its life-cycle.
	Competency 18. Requirements Management	**Element 23.** Use Requirements Management to trace back to user-defined capabilities and other sources of requirements, and to document all changes and the rationale for those changes.
	Competency 19. Risk Management	**Element 24.** Develop a Risk Management Plan to cover system and software risk elements in order to assess and manage the risks throughout the life-cycle.
		Element 25. Apply the Risk Management process across an acquisition program to manage program technical risk accounting for all relevant design considerations.
	Competency 20. Technical Data Management	**Element 26.** Evaluate how the Technical Data Management planning process is applied in the context of the Acquisition Strategy to acquire, access, manage, protect, and apply technical data during the system life-cycle.
	Competency 21. Interface Management	**Element 27.** Apply the Interface Management process to ensure interface compatibility both within the system, including software systems, and with external systems.
		Element 28. Evaluate how Interface Management techniques ensure that all internal and external interface changes in requirements are properly documented and communicated in accordance with the configuration management plan.

Units of Competence	Competencies	Competency Elements
Technical Management	**Competency 22.** Software Engineering	**Element 29.** Software Measures. Use quantitative methods to assess and track software progress against a baseline (planned vs. actual) and provide status updates in order to make timely program decisions.
		Element 30. Integration of Software and Systems Engineering. Integrate essential acquisition and sustainment activities related to software through the use of multidisciplinary teams to optimize design, manufacturing, and supportability processes.
		Element 31. Software Impact on Acquisition Strategy. Determine software-related considerations and risks that must be addressed as part of the system acquisition strategy.
		Element 32. Software Requirements. Evaluate inputs fromrelevant stakeholders that translate into functional and technical requirements that are documented, managed, traceable and verifiable through the software lifecycle process and describe the desired behavior of the software system to be built to satisfy the intended users.
		Element 33. Software Architecture. Understand the software structure of the system, including the definition of software components, and the relationships between software components, the system, and the operational architectures.
	Competency 23. Acquisition	**Element 34.** Determine the appropriate amount of systems engineering and the resources needed during each acquisition phase, across the full acquisition and system lifecycle, to achieve acceptable levels of risk for entry into the next acquisition phase.
		Element 35. Assess the proposed solution's operational viability and costs of alternative systems during the Materiel Solution Analysis (formerly called Concept Refinement) Phase, taking into account the design considerations to achieve a balanced system design.
		Element 36. Integrate proven technologies, develop new hardware/software prototypes, evaluate solutions, and determine performance requirements during the Technology Development Phase to ensure that the cost, schedule, and other constraints are met and that risks are reduced.

Units of Competence	Competencies	Competency Elements
Technical Management	**Competency 23.** Acquisition	**Element 37.** Integrate hardware, software, and human systems, protect critical program information, ensure safety and affordability, and reduce manufacturing risks during the Engineering and Manufacturing Development (formerly called System Development and Demonstration) Phase to demonstrate supportability and interoperability within incremental stages of system development.
		Element 38. Apply a Low-Rate Initial Production approach to attain Initial Operational Capability and Full Rate Production and Deployment, considering Diminishing Manufacturing Sources and Material Shortages (DMSMS); assess changes in the design of manufactur- ing processes, and apply continuous testing and evalua- tion practices during the Production and Deployment Phase to reveal manufacturing and production problems and ensure continuous enhancements to the product.
		Element 39. Plan the Logistics Management system manpower needs and support plans, and apply within a Performance-Based Logistics (PBL) environment, for the full system lifecycle, to ensure effective use of the system.
Technical Management	**Competency 24.** Systems Leadership	**Element 40.** Lead teams by providing proactive and technical direction and motivation to ensure the proper application of systems engineering processes and the overall success of the technical management process.
	Competency 25. System of Systems	**Element 41.** Translate the unique operational, and architecture considerations of System of Systems programs into the systems engineering approach.
Professional	**Competency 26.** Communication	**Element 42.** Communicate technical and complex in a clear and organized manner, both verballyand in writing, to inform and persuade others to adopt and act on specific ideas.
	Competency 27. Problem Solving	**Element 43.** Make recommendations using technical knowledge and experience, developing a clear understanding of the system, identifying and analyzing problems using a Total Systems approach, weighing the relevance and accuracy of information, accounting for interdependencies, and evaluating alternative solutions.
	Competency 28. Strategic Thinking	**Element 44.** Formulate and ensure the fulfillment of priorities, and plans consistent with the long term business and competitive interests of the organization in a global environment.
	Competency 29. Professional Ethics	**Element 45.** Maintain strict compliance to and standards of conduct in engineering and business practices to ensure integrity across the acquisition lifecycle.

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APPENDIX B. NPS SE COMPETENCY SAMPLE

Table 5. Competency: 1.0 TECHNICAL BASIS FOR COST
Career Level: SE-1 Entry Level

Knowledge, Skills & Abilities (KSA's)				
Cognitive & Affective Skill Levels	Education & Training	On the Job Experience	Professional Development	Total
Knowledge, Comprehension, Receiving Phenomena & Valuing				6
Contribute to the recording of project budget activities in accounting and financial systems	x			1
Contribute to timely and accurate full cost budget information (such as labor, procurement, travel estimates) to project managers when requested	x			1
Describe, identify or define general principles of full cost and Earned Value Management (EVM) and their application in the project environment	x			1
Describe, identify or define processes for cost estimating technical work products	x			1
Understand budgeting process and accounting and financial management techniques	x			1
Understand the project budget development process	x			1
Application, Analysis, Responding to Phenomena & Organization				2
Perform cost estimating on technical work products	x			1
Use Work Breakdown Structure (WBS) as a tool for tracking actual vs. estimated costs and use this information to revise cost models appropriately	x			1
Synthesis, Evaluation & Internalizing Values				1
Identify significant resource needs and issues for the system of interest	x			1
Grand Total				**9**

Table 6. Competency: 1.0 TECHNICAL BASIS FOR COST
Career Level: SE-2 Journey Level

Knowledge Skills & Abilities (KSA's)				
Cognitive & Affective Skill Levels	Education & Training	On the Job Experience	Professional Development	Total
Knowledge, Comprehension, Receiving Phenomena & Valuing				1
Contribute timely and accurate data (such as budget estimates) to project managers to the project budget development process		x		1
Application, Analysis, Responding to Phenomena & Organization				6
Ensure that a cost analysis requirements description (CARD) is developed and maintained		x		1
Ensure that all project needs are adequately covered and properly time phased in the budget submission for projects of low to medium complexity		x		1
Ensure that the cost estimate covers the entire project life cycle	x			1
Ensure use of advanced models and techniques for cost estimating during relevant project life cycle phases		x		1
Ensure use of straightforward and well-documented models and techniques for cost estimating during relevant project life cycle phases		x		1
Negotiate budgets and contracts with line organizations or contractors		x		1
Synthesis, Evaluation & Internalizing Values				3
Evaluate resource management products and understand their implications for the system of interest		x		1
Prepare a project-operating plan that projects the cost required to proceed according to the Project Management Plan (PMP)		x		1
Review and approve cost estimates for subsystem elements		x		1
Grand Total				**10**

Table 7. Competency: 1.0 TECHNICAL BASIS FOR COST
Career Level: SE-3 Expert Level

Knowledge Skills & Abilities (KSA's)				
Cognitive & Affective Skill Levels	Education & Training	On the Job Experience	Professional Development	Total
Knowledge, Comprehension, Receiving Phenomena & Valuing				1
Describe, identify or define processes and techniques for working with stakeholders to effectively deal with a dynamic budget environment	x			1
Synthesis, Evaluation & Internalizing Values				1
Evaluate and reconcile independent cost estimates with advocacy cost estimates			X	1
Grand Total				**2**

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APPENDIX C. DAU SPRDE-SE LEVEL III COURSE DATA

Table 8. ACQ 201B Data

COURSE	CL/PO ELO		BLOOM'S CATEGORY	DAU COMPETENCY
ACQ201B	1.0	Determine how IPT leadership concepts can be used to overcome barriers to effective teamwork, based on real world experience.	comprehension	24.0 Systems Engineering Leadership
ACQ201B	1.1	**Relate** key tenets of IPPD to planning and executing an acquisition program.	knowledge	24.0 Systems Engineering Leadership
ACQ201B	1.2	**Identify** the aids and barriers to successful IPT implementation.	knowledge	24.0 Systems Engineering Leadership
ACQ201B	1.3	**Identify** the Supervisory, Participative and Team leadership styles.	knowledge	24.0 Systems Engineering Leadership
ACQ201B	1.4	**Describe** how different leadership styles impact the effectiveness of an IPT.	comprehension	24.0 Systems Engineering Leadership
ACQ201B	1.5	**Identify** the behaviors and characteristics of effective teams.	knowledge	24.0 Systems Engineering Leadership
ACQ201B	2.0	Resolve an acquisition-related dilemma by prioritizing ethical values and considering how choices impact the welfare of others.	application	29.0 Professional Ethics
ACQ201B	2.1	**Identify** the characteristics of a "successful" defense acquisition program from a variety of perspectives.	knowledge	29.0 Professional Ethics
ACQ201B	2.2	**Identify** core ethical values critical to decision making in the acquisition environment.	knowledge	29.0 Professional Ethics
ACQ201B	2.3	**Identify** the steps of the Principled Decision Making Model.	knowledge	29.0 Professional Ethics
ACQ201B	2.4	**Resolve** an ethical dilemma by **applying** the steps of the Principled Decision Making .Model.	application	29.0 Professional Ethics
ACQ201B	3.0	Evaluate alternative approaches to meet a needed capability based on affordability, schedule and technical considerations.	evaluation	14.0 Decision Analysis
ACQ201B	3.1	Given a user's requirement and selected concept, **select** an appropriate approach from the perspective of the system developer, to meet the requirement.	knowledge	14.0 Decision Analysis
ACQ201B	3.2	**Identify** the three major dimensions of program risk used to analyze technical approaches during the Materiel Solution Analysis Phase (cost, schedule and performance).	knowledge	19.0 Risk Management
ACQ201B	3.3	**Identify** the concept of Cost as an Independent Variable (CAIV) in relation to an acquisition program.	knowledge	1.0 Technical Basis for Cost
ACQ201B	3.4	**Relate** the concepts of affordability and Cost as an Independent Variable (CAIV) to the planning of an acquisition program.	knowledge	1.0 Technical Basis for Cost
ACQ201B	3.5	Working in a student-led IPT, **demonstrate** the behaviors and characteristics of an effective team.	application	24.0 Systems Engineering Leadership

ACQ201B	4.0	Prepare an acquisition strategy program structure chart showing appropriate interrelationship(s) of the various business and technical functions involved in planning and executing the program.	**analysis**	15.0 Technical Planning
ACQ201B	4.01	Given an acquisition program scenario with information on technology maturity, funding and JCIDS documentation, **identify** the correct starting point for the program in the acquisition lifecycle.	**analysis**	15.0 Technical Planning
ACQ201B	4.02	**Identify** the correct type appropriated funds needed by phase and work effort.	**comprehension**	15.0 Technical Planning
ACQ201B	4.03	Given an acquisition program structure chart **identify** the correct sequence and timing of technical reviews by phase and work effort.	**analysis**	15.0 Technical Planning
ACQ201B	4.04	Given an acquisition program structure chart **identify** the correct sequence and timing of developmental and operational test events by phase and work effort.	**analysis**	15.0 Technical Planning
ACQ201B	4.05	Given an acquisition program structure chart **identify** the correct sequence and timing of lifecycle logistics planning and execution efforts by phase and work effort.	**analysis**	15.0 Technical Planning
ACQ201B	4.06	Given an acquisition program structure chart, identify the appropriate contract types by phase and work effort.	**analysis**	15.0 Technical Planning
ACQ201B	4.07	Given an acquisition program structure chart, **identify** the timing of major hardware deliverables by phase and work effort.	**analysis**	15.0 Technical Planning
ACQ201B	4.08	**Relate** the capability documents (ICD,CDD,CPD) to the correct phases of the acquisition system.	**knowledge**	23.0 Acquisition
ACQ201B	4.09	**Identify** the evolutionary acquisition strategy approach.	**knowledge**	23.0 Acquisition
ACQ201B	4.10	**Identify** the single step acquisition strategy approach.	**knowledge**	23.0 Acquisition
ACQ201B	5.0	Modify, present, and defend an acquisition strategy to accommodate a change in program funding levels.	**synthesis**	23.0 Acquisition
ACQ201B	5.01	**Identify** the proper response to a program funding cut.	**comprehension**	23.0 Acquisition
ACQ201B	5.02	Given a program funding cut **identify the potential** impacts on industry.	**comprehension**	23.0 Acquisition
ACQ201B	6.0	Develop portions of a source selection plan, including source selection criteria.	**synthesis**	Contract Management
ACQ201B	6.01	**Identify** how the Government communicates performance requirements in solicitations.	**knowledge**	Contract Management
ACQ201B	6.02	**Identify** the role of various IPT members in developing the solicitation.	**knowledge**	Contract Management
ACQ201B	6.03	**Identify** the purpose of evaluation criteria and how the criteria are developed.	**knowledge**	Contract Management
ACQ201B	6.04	**Develop** evaluation criteria in a source selection.	**synthesis**	Contract Management
ACQ201B	7.0	Apply the iterative SE steps to develop outputs of the systems engineering process in order to verify they meet a given requirement.	**application**	23.0 Acquisition
ACQ201B	7.1	Given a summary Capability Development Document (CDD) and a system concept, **determine** whether the concept addresses all user requirements.	**application**	5.0 Requirements Analysis
ACQ201B	7.2	**Identify** the overall purpose of the systems engineering process.	**knowledge**	30.0 Systems Thinking
ACQ201B	7.3	**Identify** the technical processes that make up the overall systems engineering process.	**knowledge**	23.0 Acquisition
ACQ201B	7.4	**Identify** the technical management processes used to control and manage the overall systems engineering process.	**knowledge**	23.0 Acquisition
ACQ201B	7.5	**Identify** the main inputs and outputs of the overall systems engineering process.	**knowledge**	23.0 Acquisition
ACQ201B	7.6	Given an acquisition scenario within an IPT environment, **develop** and present selected outputs of the systems engineering process steps.	**synthesis**	23.0 Acquisition

ACQ201B	8.0	Given a program schedule, explain the role of test and evaluation (DT&E, OT&E, LFT&E) in the systems engineering and acquisition management processes.	comprehension	9.0 Verification
ACQ201B	8.1	**Identify** the characteristics and purposes of Developmental Test and Evaluation (DT&E).	knowledge	9.0 Verification
ACQ201B	8.2	**Identify** the characteristics and purposes of Operational Test and Evaluation (OT&E).	knowledge	9.0 Verification
ACQ201B	8.3	**Identify** the characteristics and purposes of Live Fire Test and Evaluation (LFT&E).	knowledge	9.0 Verification
ACQ201B	8.4	Given a test event description, correctly **identify** the type of testing being accomplished.	comprehension	9.0 Verification
ACQ201B	8.5	Given a program schedule, correctly **identify** opportunities for combined DT/OT.	comprehension	9.0 Verification
ACQ201B	8.6	**Identify** the risks and benefits associated with combining DT and OT events.	knowledge	9.0 Verification
ACQ201B	9.0	Analyze actual verses planned technical performance data in risk areas to indicate potential problems that may prevent a system from being operationally effective and suitable.	analysis	19.0 Risk Management
ACQ201B	9.1	**Identify** potential risk areas based on technical performance data.	analysis	19.0 Risk Management
ACQ201B	9.2	**Identify** the role of technical performance measures in the systems engineering process.	knowledge	16.0 Technical Assessment
ACQ201B	10.0	Given a segment of contract work and associated tasks, plan and schedule the tasks and resources necessary to complete contract work within cost and schedule constraints.	synthesis	Contract Management
ACQ201B	10.1	Apply the fully burdened rate to labor hours to correctly **calculate** contractor's costs.	application	Contract Management
ACQ201B	10.2	**Distinguish** correctly between direct and indirect costs on a contract.	comprehension	Contract Management
ACQ201B	10.3	Given a simple Gantt chart with defined task relationships, **identify** the critical path.	comprehension	15.0 Technical Planning
ACQ201B	10.4	Given a completed Gantt chart with the critical path identified, **identify** cost and schedule risks in the plan.	comprehension	15.0 Technical Planning
ACQ201B	10.5	Given a completed Gantt chart with the critical path identified, **explain** cost and schedule risks in the plan.	comprehension	15.0 Technical Planning
ACQ201B	11.0	Select a best value contractor by comparing contractor proposals and test results to source selection criteria.	analysis	Contract Management
ACQ201B	11.1	**Apply** evaluation criteria in a source selection.	application	Contract Management
ACQ201B	11.2	**Identify** the best value approach to source selection.	knowledge	Contract Management
ACQ201B	11.3	**Apply** a selected quantitative tool (e.g. decision matrix) to resolve a problem.	application	14.0 Decision Analysis
ACQ201B	12.0	The student will be able to analyze and contractor performance indicators to identify trends and problems.	analysis	Contract Management
ACQ201B	12.01	Given earned value data **calculate** cost variance, schedule variance, cost performance index and schedule performance index.	application	Contract Management
ACQ201B	12.02	Given cost variance, schedule variance, SPI & CPI **explain** the program's cost and schedule status.	comprehension	Contract Management
ACQ201B	12.03	Given the Actual Cost, Target Cost, Target Profit, Target Price, Share Line, and Ceiling Price on a Fixed Price Incentive Firm Target Contract, correctly **calculate** the Final Contract Price.	application	Contract Management
ACQ201B	13.0	Given a scenario, apply key software acquisition management principles needed to make sound decisions for planning and executing an acquisition program.	application	22.0 Software Engineering
ACQ201B	13.01	**Identify** common ways that software-intensive projects have gotten into trouble.	knowledge	22.0 Software Engineering
ACQ201B	13.02	**Identify** “Best Practices” that may be appropriate for the acquisition of software-intensive systems.	comprehension	22.0 Software Engineering

ACQ201B	13.03	**Identify** the aspects of the Net Ready KPP as it applies to acquisition of Information Technology (e.g. interoperability, architecture, information assurance).	comprehension	22.0 Software Engineering
ACQ201B	13.04	**Identify** the benefits and risks associated with using Commercial Off The Shelf (COTS) .software	knowledge	22.0 Software Engineering
ACQ201B	13.05	**Explain** the relationship between software development activities and the systems engineering process.	comprehension	22.0 Software Engineering
ACQ201B	13.06	**Explain** the impact of a new requirement on various functional areas.	comprehension	22.0 Software Engineering
ACQ201B	13.07	**Identify** the impacts of a new program requirement on the following functional areas: Program Management, Systems Engineering, Contracting, Lifecycle Logistics, Financial Management, Software Acquisition Management, & Test and Evaluation.	comprehension	22.0 Software Engineering
ACQ201B	14.00	Analyze a reliability problem from multiple perspectives and select and defend a solution.	evaluation	13.0 Reliability, Availability, and Maintainability
ACQ201B	14.01	**Explain** the interrelationship between selected functional areas (e.g., contracting, finance, systems engineering) and acquisition logistics.	comprehension	13.0 Reliability, Availability, and Maintainability
ACQ201B	14.02	**Explain** why it is important to influence system design for supportability.	comprehension	13.0 Reliability, Availability, and Maintainability
ACQ201B	14.03	**Explain** the relationship of Reliability, Availability, and Maintainability (RAM) to Acquisition Logistics, and its impact on system performance, operational effectiveness (including support), logistics planning, and life-cycle cost.	comprehension	13.0 Reliability, Availability, and Maintainability
ACQ201B	14.04	**Identify** the impacts of a supportability problem on the following functional areas: Program Management, Systems Engineering, Contracting, Lifecycle Logistics, Financial Management, Quality Assurance & Manufacturing, & Test and Evaluation.	application	13.0 Reliability, Availability, and Maintainability
ACQ201B	14.05	**Explain** how instability of requirements, design, and production processes impact program cost and schedule.	comprehension	13.0 Reliability, Availability, and Maintainability
ACQ201B	15.00	Given a scenario, identify the major contract administration activities.	comprehension	Contract Management
ACQ201B	15.01	**Explain** the interrelationship between selected functional areas (e.g., life cycle logistics, finance, systems engineering) and contracting.	comprehension	Contract Management
ACQ201B	15.02	**Identify** the causes and consequences of constructive changes.	knowledge	Contract Management
ACQ201B	15.03	**Identify** the complementary roles and responsibilities of the contracting officer and the program manager in their partnership throughout the acquisition process.	knowledge	Contract Management
ACQ201B	16.00	Given a scenario, apply the procedures, rules and public laws associated with the execution of DoD budgets.	analysis	23.0 Acquisition
ACQ201B	16.01	**Identify** the public laws (i.e., Misappropriation Act, Anti-deficiency Act, Bona Fide Need Rule) that apply to the use of appropriated funds in DoD acquisition.	comprehension	23.0 Acquisition
ACQ201B	16.02	**Select** the appropriate public law (i.e., Misappropriation Act, Anti-deficiency Act, Bona Fide Need Rule) that applies to the use of appropriated funds **under specific circumstances**.	comprehension	23.0 Acquisition

ACQ201B	17.00	Analyze the elements of manufacturing as they relate to a systems performance problem using a qualitative tool (cause and effect/fishbone diagram).	analysis	14.0 Decision Analysis
ACQ201B	17.01	**Identify** the elements of manufacturing (5Ms).	knowledge	6.0 Architecture Design
ACQ201B	17.02	**Explain** the considerations/concerns of the elements of manufacturing (5Ms) and how other areas are affected.	comprehension	6.0 Architecture Design
ACQ201B	17.03	**Explain** the impact of manufacturing on cost, schedule and performance.	comprehension	6.0 Architecture Design
ACQ201B	17.04	**Explain** the use of the 5 Whys root cause determination method in identifying potential root causes.	comprehension	14.0 Decision Analysis
ACQ201B	17.05	**Explain** the multi-voting technique to narrow large lists of possibilities into smaller, more manageable, lists.	comprehension	14.0 Decision Analysis
ACQ201B	18.00	Analyze the impact of supportability issues on system readiness/performance and other functional areas. E.g. contracts, finance, systems engineering and acquisition logistics.	analysis	23.0 Acquisition
ACQ201B	18.01	**Synthesize** several approaches to solving a program supportability issue (obsolescence).	synthesis	23.0 Acquisition
ACQ201B	18.02	**Evaluate** approaches to solving a program supportability issue (obsolescence).	evaluation	23.0 Acquisition
ACQ201B	18.03	**Recommend** the best to solving a program supportability issue (obsolescence).	evaluation	23.0 Acquisition
ACQ201B	18.04	**Identify** the proper DoD Appropriation Category to be used to budget for each of the three phases of a Product Improvement Program.	comprehension	23.0 Acquisition
ACQ201B	18.05	**Assess** the impact of the failure to execute funds in accordance with program plans.	knowledge	23.0 Acquisition
ACQ201B	18.06	**Recognize** how configuration management impacts all functional disciplines (e.g., test, logistics, manufacturing, etc.).	comprehension	17.0 Configuration
ACQ201B	18.07	**Demonstrate** the interrelationship between selected functional areas, e.g., contracting, finance, systems engineering, and life cycle logistics.	comprehension	23.0 Acquisition
ACQ201B	18.08	**Identify** tools/best practices/techniques available in the systems engineering process to achieve the principal goals of supportability analyses.	knowledge	23.0 Acquisition
ACQ201B	18.09	**Apply** performance based metrics to a program supportability problem (e.g. obsolescence).	application	23.0 Acquisition
ACQ201B	18.10	**Apply** performance or outcome based logistics principles to solving a program obsolescence issue.	application	23.0 Acquisition

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